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THE COAST SIGNAL SYSTEM.

By F. B. ANDERSON, Late Lieut. of U. S. N.

The first official recognition of the possibilities of a coast signal service in connection with the United States Navy was taken when the present Secretary of the Navy issued an order under date of the 18th of October, 1897, appointing a board for the purpose of considering the advisability of coast signal stations as part of the scheme of naval defense.

Commander John Schouler, U. S. N., was named as senior member, the other members being Lieut. C. H. Harlow, U. S. N., then acting as flag lieutenant of the North Atlantic Squadron, and Lieut. J. H. Gibbons, U. S. N., then stationed at the Navy Department and in charge of the Naval Militia Bureau; an invitation was extended to the writer to act as a voluntary member, and accepted.

In accordance with these orders the board assembled at the Navy Department in Washington, D. C., on October 25, 1897, and devoted a great many hours to the consideration of the systems of coast signal stations that had been established in other countries, to the needs of our own coasts, and to the existing means of communication between ships and shore.

The board recognized the important part that properly established signal stations would play in the defense of the country, and made the following report:

NAVY DEPARTMENT,
Washington, D. C., October 27th, 1897.

SIR:—In obedience to an order of the Department, dated October 18, 1897, a copy of which is hereto attached, the board appointed for the purpose of considering the coast signal stations for naval defense, met at 10 A. M. on the 25th instant at the Navy Department.

After consideration of the question the board has the honor to submit the following report:

The board regards the question of communication as divided into two heads—

(*a*) From the sea to the shore.

(*b*) From the shore to the sea; and in its recommendation it has kept in mind such means of communication as are already recognized and established in the naval service within easy reach of the naval militia, and the possibility of enlisting the cooperation of the Treasury Department for using the life-saving stations, particularly such as are or might easily be put in telegraphic communication with headquarters.

(*a*) COMMUNICATION FROM SEA TO SHORE.

Considering the importance of receiving information from a distance beyond the range of visibility, there seems to be but one method which has already had sufficient success to warrant the board recommending it as the best method for communicating from a fleet, scouting vessels, or picket boat at distances ranging from 10 to 50 miles, with a possible extension to 100 miles—the homing pigeon. This, of course, is limited entirely to daylight; but inasmuch as the same difficulties which militate against the successful use of the homing pigeon are present with the fleet or scouting vessels in obtaining information, the board is of the opinion that this service, which already exists in the Navy Department, should be so extended as to cover such points of the coast as are within the control of the Treasury Department or the various State naval militias. At night the use of the search-light for distance of perhaps 10 miles, and the Very's night signals within 15 miles, have been experimented with to such degree of success as to warrant its recommending these two methods for communicating from sea to shore after nightfall.

(*b*) COMMUNICATION FROM SHORE TO SEA.

It is not believed that any system of flags in itself can be relied upon with any certainty, considering the difficulties which a calm, on-shore wind, a hazy atmosphere, and the peculiar character of a shore background present. The board is therefore of the opinion that some system based on the use of shapes or semaphores is the only one which can be relied upon. There already exists in section 1, part 3, of the International

Code of Signals, with which all life-saving stations are either supplied or can easily be supplied, a system of distant signals requiring (1) a ball, pennant and square flag or (2) a 3-armed semaphore. The semaphore, however, should be fitted with four elements instead of three, as it is believed that the holding of the display for any appreciable length of time is of much greater value than the temporary transient display which it is necessary to make with any semaphore having less than the four elements.

It is thought that these 4-armed semaphores can readily be made to conform to existing codes or such codes as could be easily and quickly adapted to meet the peculiar character of the information which they are likely to be called upon to transmit. The board believes that it is necessary for these stations to have men thoroughly conversant with the wig-wag code, and that as far as possible it be required that they must be prepared to receive messages which are sent by this code. It is also believed that the semaphore or shape systems can be readily adopted to meet the demands of the wig-wag code.

It is believed that the means of transmission of intelligence from such stations as may be selected to the main telephone and telegraph wires either already exist or can, with the assistance of the naval militia, quickly be installed and afford a certain method of transmitting intelligence to headquarters.

Having those systems in mind, the board has so subdivided the coast that the important centers, such as naval stations or strategic points, shall be amply protected by the methods proposed; and it has the honor to submit herewith the points at which, in its opinion, homing-pigeon cotes and semaphore apparatus should be installed, and steps be taken to instruct a sufficient number of men at each one of them in the use of these appliances, so that the system may be carried on at least experimentally until more specific arrangements can be made for their care and maintenance. (See Appendix A.)

The board is fully of the opinion that the general supervision of this system of coast signal stations for naval defense should be under the direction of the Navy Department, each State having control of such subsidiary stations as may exist or be established within its limits; that there should be a general supervision exercised by the regular service in such a way that there should be no departure by any one of the districts from the general scheme, which is to be directed by the Navy Department. It believes that a semi-annual inspection by some officers appointed by the Department would be sufficient for this purpose, and that it will devolve upon the naval militia to make also a semi-annual report as to the efficiency of such stations as they may establish in their districts.

It is suggested that the naval militia can very properly take charge of all lines of communication within their districts, establish subsidiary stations in connection with the coast signal stations, keep in touch with the men, and prepare plans for the rapid connection of all stations with the long-distance telephone and telegraph systems of the country. Further, that they make such arrangements with the different telegraph com-

panies as will enable them to keep their information up to date and be able to report all changes to the Navy Department.

Any scheme of this nature will, of course, require the cooperation of the Treasury Department. The naval features of it should be, in the opinion of the board, under the direction of the Bureau of Equipment, and steps should be taken by the Navy Department to secure such cooperation of the Treasury Department as will insure an intelligent assistance in matters of naval defense.

It is believed, as essential to the success of this scheme, that some extra compensation should be awarded to the men that may be called upon to take charge of and manipulate the plant at the various stations.

The board is of the opinion that a compensation at the rate of $5 per month extra for the keeper of each station should be given, and that a certain standard of proficiency in the use of signals be adopted; and, further, that a reward of $10 be held out each six months for all such persons employed at the stations as may be, upon inspection, found to reach the standard.

It is not thought to be within the province of the board to go into details of either pigeon cotes, construction of semaphores, or other methods of signaling. The Bureau of Equipment is already supplied with sufficient information to render the installation of these methods a very simple matter. Their expense, of course, will have to be a subject for special appropriation, but it is not believed that the sum total for all stations will amount to any very considerable sum.

JOHN SCHOULER,
Commander, U. S. N., Senior Member of Board.

C. H. HARLOW,
Lieutenant, U. S. N., Member.

J. G. GIBBONS,
Lieutenant, U. S. N., Member.

FRANK B. ANDERSON,
Lieutenant, Signal Officer Naval Militia of New York, Voluntary Member.

APPENDIX A.

There already exist homing-pigeon cotes at Portsmouth, N. H.; Newport, R. I.; Navy Yard, N. Y.; Norfolk, Va.; Key West, Fla.; Mare Island, Cal.; Assateague Beach, Va., and Cape Hatteras, N. C.

It is proposed to utilize the following life-saving stations:

Machias, Cross Island, Me.

White Head, Me.

The Highland Lights, Cape Cod, Mass.

Chatham, Mass.

Shinnecock, Long Island.

Fire Island, Long Island.

U. S. S. New Hampshire, headquarters First Battalion New York Naval Militia.

Barnegat, N. J.
Atlantic City, N. J.
Wilmington, N. C. (to be governed by its connection with the North Carolina State Militia).
Tybee Island, Ga. (to be governed by its connection with the Georgia State Militia).
St. Augustine, Fla. (to be governed by its connection with the Florida State Militia).
Jupiter Inlet, Fla.
Tampa Bay, Fla.
Pensacola, Fla.
Port Eads, La. (to be governed by its connection with the Louisiana State Militia).
Galveston, Tex.
San Diego, Cal. (to be governed by its connection with the California State Militia).
Port Canby, Cape Disappointment, Wash.
Cape Flattery, Neah Bay, Wash.

The Bureau of Navigation concurred with the board in its recommendations, and the report was forwarded to the Secretary of the Navy, who approved it and returned it to the Bureau of Navigation with orders to take such steps as were necessary for carrying out the recommendations.

The Lighthouse Board and Life-saving Service were consulted, and both heartily entered into the plan, both stating that they would be glad to lend assistance fully and unreservedly.

On February 24, 1898, the acting chief of the Bureau of Navigation stated, in a memorandum to the Bureau of Equipment, that the Bureau believed that the Department was now in possession of sufficient information to warrant the establishment of one or more of the signal stations, and suggested that the first station be established at the Highland Lights, Highland of Navesink, or at Fire Island.

On looking back it seems a pity that this suggestion was not acted upon, as many problems that had to be experimented with during the emergencies of war would have been confronted and solved.

The Naval Militia entered enthusiastically into their share of the work, and spent time and money familiarizing themselves with the telegraph and telephone facilities of their localities; enlisted some of the most expert telegraphers from the ranks of the Associated Press dispatchers, charted the routes of all the

trunk lines and sent reconnoitering parties down the beaches to observe the routes of the life-saving telephone lines and actual situation and surroundings of the lighthouses and life-saving stations. Sites for signal stations were selected and every possible preparation made to carry out the ideas of the Navy Department.

On March 15, 1898, Captain C. F. Goodrich, U. S. N., was ordered, in addition to his other duties, to make and report with all practicable dispatch, a preliminary plan of arrangements for establishing a coast signal service on the Atlantic and Gulf seaboards. Captain Goodrich visited all of the principal cities on the Atlantic and Gulf coasts, conferring with the commanding officers of the Naval Militia in each State; he designated the points at which stations were to be located, what gear was to be used, etc., and requested the Naval Militia officers to ascertain the cost of erecting the houses for the shelter of the crews, the cost of the signal masts, flags and other gear, and to obtain bids from responsible persons, agreeing to do the work within a specified time; impressing on all, that the stations must all be established, manned and in full working order in ten days from the time the order was given to commence work; also, to arrange with private owners of land for the occupation of the land during the continuance of the war.

On this trip Captain Goodrich came in personal contact with the officers of the Naval Militia, and the impressions formed no doubt influenced him greatly in picking out the men whose names he sent into the Navy Department for assignment to command of the several districts.

On April 9, Captain Goodrich having reported, the Secretary of the Navy issued the following order:

April 9, 1898.

SIR:—You will at once establish the coast-line system of signal stations for national defense, according to the plans indicated in your reports to the Department. You are put in entire charge of this work, and are responsible for its details, but you will consult from time to time with the board now considering the policy of the Department in matters of offense and defense, and with them will determine just which stations should be established.

Upon your request the bureaus and offices of the Department will give you such assistance as may be necessary to carry the plans into effect.

Seventy-five thousand dollars from the appropriation for national

defense has been allotted by the President for the purpose of establishing this system of signal stations. Very respectfully,

JOHN D. LONG,
Secretary.

Capt. CASPAR F. GOODRICH, U. S. N.,
Washington, D. C.

On April 12, Captain Goodrich wrote to the commanding officers of the Naval Militia organizations giving the full list of stations to be established, dividing the two coasts into districts and giving a detailed statement of the number of men allowed at each station, their ratings and also a list of the signal and mess gear that the Department would allow.

On April 12, Captain Goodrich also wrote to the President of the Board on the Plan of Campaign, giving in detail the districts into which he had divided the coasts, the stations in each district, and wrote as follows: "My plans are in such a state of forwardness that practically any one of these stations can be occupied within twenty-four hours and an improvised means of receiving and transmitting signals immediately organized. To permanently equip these stations will take from ten days to perhaps three weeks, depending upon accessibility of the station and its proximity to a great commercial center, whence men and materials can be quickly drawn. In view of extemporizing a service on demand, and of the short time required to place a complete scheme in operation, the board yesterday, as I understand, agreed that, under the circumstances, it was advisable to delay expending the money allotted for the erection of masts and buildings until the necessity should absolutely arise; upon this understanding I am acting."

On the same day Captain Goodrich acknowledged the receipt of the Department's orders to establish the coast signal stations, and advised the Department of the decision of the Board on the Plan of Campaign.

On April 22, he received orders to telegraph the different Naval Militia organizations to establish the coast signal stations, and immediately sent the following message to all the States concerned:

"Establish and man coast signal stations already determined by me. Lowest bids; greatest economy; most speed necessary; let crews sign temporary agreement pending receipt of enlist-

ment forms. No heliographs needed. Send future communications, Superintendent, New York."

GOODRICH.

These telegrams were received late in the evening on the 22d of April, and by midday of the 23d, messages began to come in from up and down the coast, stating that improvised signal stations were ready, and in from ten days to two weeks all stations, with the exception of a few on the Florida coast, located at very inaccessible places, had reported as fully equipped.

Prior to the final order to man the stations, and for ten days after that order was issued, the details of the work in the second district came under my personal supervision, and I feel more intimately acquainted with the work done in that district than that done in any other.

Every class of citizen that I was brought in contact with added something to expedite the work, in spite of the fact that it is rather unusual for a contractor to bind himself to do rush work under a penalty on an uncertainty. Our instructions were not to spend a cent, or to in any way commit the Government until we received our final orders; even when these orders came we were not accredited representatives of the Government, as we did not pass our examinations and receive our commissions until some ten days afterwards. Every department of commercial undertaking was choked with orders for war material of every character; prices went up with a rush, and it was only by using personal acquaintance and friendship that we were able to hold the prices down to the figures which we had sent in to the Department.

The telegraph and telephone companies rushed the work of constructing loops from their trunk lines to the signal stations and to the U. S. S. New Hampshire, which was moored at the foot of East 28th Street, New York City, and was used as headquarters of the 2d District, and, in fact, as the headquarters of the whole system of stations until the latter headquarters was transferred to Washington.

Assurances had been obtained from the civilian employers of the Naval Militiamen that their positions would be held open for them, and arrangements made with the State Government by which the men were paid and fed until such time as the National Government could muster them into the service.

Through the kindness of the Lighthouse and Life-saving Services, the men were sheltered until their shanties could be built, and in such places as it was impossible to use these services, the men lived under canvas.

Building materials, spars, mess gear and signal gear were rushed forward as rapidly as possible; in several instances the freight cars on which the spars and lumber were loaded were hooked on to passenger trains through the courtesy of the railroad officials.

The inhabitants of the towns near coast signal stations for some reason seemed to gather some sense of security on account of having the stations near them, and helped the crews in every conceivable way. One gentleman at Babylon, Long Island, used his fast pleasure steam yacht to carry mail and supplies to Fire Island, and kept this service up during the entire war, making two trips a day and special trips when signaled for.

On April 23, Captain Goodrich was relieved from command of the Coast Signal Service and Captain Theo. F. Kane, U. S. N. (retired) was appointed to succeed him, and on May 9, Captain Kane was relieved and was succeeded by Captain John R. Bartlett, U. S. N. (retired), then in charge of the office of Naval Intelligence. Captain Bartlett came on to New York, assumed command and moved the general headquarters to Washington, where it remained during the war.

Owing to the fact that the men had been sent to the stations without physical examination and without being mustered into the Navy, two surgeons and two line officers were immediately sent out to examine them and muster them in.

Regulations for the government of the service were prepared, printed, and issued, and provision was made for the care of the sick or injured, the Surgeon-General of the Marine Hospital Service cooperating at once on application. Medicine chests, containing simple remedies and directions for the treatment of simple ailments, were at once issued. Log books and inspection blanks, and forms for the return of property, were printed and distributed; routines of watches and drills established; a list of all the stations was printed and issued to all steamship companies; a "Notice to Mariners" was given to the Associated Press, calling attention to the location of the stations, and asking all ship captains to report anything of interest, and advising them that the stations would notify them of any news affecting their safety.

The cooperation of the Lighthouse Establishment, Life-saving Service and Weather Bureau, was sought and granted at once. The Lighthouse authorities pushed the work of connecting all of their most important Light Stations with the telephone systems of the country. The Life-saving Service had the majority of its stations connected by telephone with each other, with outlets at a number of points to the commercial lines, and the Weather Bureau had telegraph communication with all of its stations. By connecting the Coast Signal Stations with the Weather Bureau and Life-saving lines, the Navy Department had complete control of the beaches, and the coast signal stations had communication up and down the beaches as well as inland. Added to this, the life-saving system of patrolling the beaches each night placed every foot of the seacoast as far south as Ocracoke Inlet under the watchful eyes of men who had been trained for years to observe everything that floated and to endure every hardship.

The location of every army headquarters on the seaboard and of every fort or battery was charted, and information was sent out to each district telling how they could be communicated with in case of necessity. This information was also sent to the stations by the district officers.

Owing to the fact that the life-saving crews are laid off during the months of June and July, and that the coast signal service would lose a very valuable, if not its most valuable, ally, it became necessary to bring about legislation that would allow the retention of the majority of these stations in commission, and that would furnish the money necessary to pay the crews. This was accomplished, and the bill appropriating seventy-five thousand dollars became a law on June 7, 1898. It might be interesting to note that the fact of the life-saving stations being in commission during the usual off months, resulted not only in perfecting the system of signal stations, but in rendering valuable aid to the San Francisco when she went ashore, and in the saving of lives and property from several wrecks that occurred during the summer.

Experience taught the necessity of changing the location of some of the stations and the final distribution was as follows:

APPENDIX I.

List of Stations of the Coast Signal Service on the Atlantic and Gulf Coasts of the United States.

[Navy Department, Washington, D. C., United States Coast Signal Service. John R. Bartlett, Captain, U. S. N., Superintendent.]

[Light-houses, life-saving stations, and Weather Bureau stations are co-operating with the United States Coast Signal Service. Messages will be sent direct to headquarters at Washington from all these stations.]

LIST OF DISTRICTS.

First district, United States Coast Signal Service, West Quoddy Head, Maine, to Gay Head, Marthas Vineyard, inclusive; headquarters, U. S. S. Minnesota, Boston, Mass.

Second district, Block Island, R. I., to Cape Henlopen, Del., inclusive; headquarters, U. S. S. New Hampshire, New York City, N. Y.

Third district, Cape Henry, Va., to Cape Fear, inclusive, headquarters, Navy Yard, Norfolk, Va.

Fourth district, Georgetown, S. C., to St. Simons Island, Ga., inclusive; headquarters, Light-House Inspector's Office, Charleston, S. C.

Fifth district, mouth St. Johns River, Fla., to Cape Florida, inclusive; headquarters, Jacksonville, Fla.

Sixth district, Key West, Fla., to Egmont Key, Fla., inclusive; headquarters, Port Tampa, Fla.

Sixth-A district, Santa Rosa Island, Fla.; headquarters, Navy Yard, Pensacola.

Seventh district, Mobile, Ala., to Galveston, Tex., inclusive; headquarters, Armory Naval Battalion, New Orleans, La.

STATION.	LOCATION.	STATE.
Light-house	West Quoddy Head	Maine.
Life-saving station	Quoddy Head	Do.
Light-house	Moose Peak	Do.
Do	Baker Island	Do.
COAST SIGNAL STATION	do	Do.
Do	Lanes Island, Vinal Haven	Do.
Light-house	Owls Head	Do.
Do	White Head	Do.
Life-saving station	do	Do.
Light-house	Marshall Point	Do.
Life-saving station	Hunniwells Beach	Do.
Light-house	Pond Island	Do.
Do	Cape Elizabeth	Do.
COAST SIGNAL STATION	do	Do.
Light-house	Cape Neddick	Do.
Life-saving station	Jerrys Point	New Hampshire.
COAST SIGNAL STATION	Appledore Island, Isle of Shoals	Do.
Life-saving station	Rye Beach	Do.
Do	Salisbury Beach	Massachusetts.
Light-house	Newburyport	Do.
Life-saving station	Plum Island	Do.
Do	Knobbs Beach	Do.

Station.	Location.	State.
Coast signal station	Cape Ann (Rockport)	Massachusetts.
Light-house	Cape Ann, Thatchers Island	Do.
Do	Eastern Point	Do.
Life-saving station	Point Allerton	Do.
Light-house	Plymouth (Gurnet)	Do.
Do	Race Point, Cape Cod	Do.
Life-saving station	do	Do.
Do	Peaked Hill Bars	Do.
Do	High Head	Do.
Do	Highland	Do.
Coast signal station	Cape Cod Light	Do.
Life-saving station	Pamet River	Do.
Do	Cahoons Hollow	Do.
Light-house	Nauset Beach	Do.
Life-saving station	do	Do.
Do	Orleans	Do.
Do	Old Harbor	Do.
Do	Chatham	Do.
Weather Bureau	do	Do.
Life-saving station	Monomoy	Do.
Light-house	do	Do.
Do	Great Point (Nantucket)	Do.
Life-saving station	Coskata (Nantucket)	Do.
Weather Bureau	Nantucket	Do.
Light-house	Sankaty Head (Nantucket)	Do.
Life-saving station	Surfside (Nantucket)	Do.
Do	Great Neck (Nantucket)	Do.
Light-house	Hyannis	Do.
Weather Bureau	Vineyard Haven, Marthas Vineyard	Do.
Light-house	Gay Head, Marthas Vineyard	Do.
Coast signal station	do	Do.
Light-house	Dumpling Rock, Buzzards Bay	Do.
Do	Point Judith	Rhode Island.
Life-saving station	do	Do.
Do	Watch Hill	Do.
Light-house	Sandy Point (north light), Block Island	Do.
Do	Southeast Light, Block Island	Do.
Coast signal station	Block Island Light, Block Island	Do.
Do	Montauk Point, Long Island	New York.
Light-house	do	Do.
Life-saving station	Ditch Plain, Long Island	Do.
Do	Hither Plain, Long Island	Do.
Do	Napeague Beach, Long Island	Do.
Life-saving station	Amagansett, Long Island	Do.
Do	Georgica, Long Island	Do.
Do	Mecox, Long Island	Do.
Do	Southampton, Long Island	Do.
Do	Shinnecock, Long Island	Do.
Light-house	do	Do.
Life-saving station	Tiana, Long Island	Do.
Do	Quogue, Long Island	Do.
Coast signal station	do	Do.
Life-saving station	Petunk, Long Island	Do.
Do	Moriches, Long Island	Do.
Do	Forge River, Long Island	Do.
Do	Smiths Point, Long Island	Do.
Do	Bellport, Long Island	Do.
Do	Blue Point, Long Island	Do.
Do	Lone Hill, Long Island	Do.
Do	Point of Woods, Long Island	Do.

STATION.	LOCATION.	STATE.
Coast signal station	Fire Island, Long Island	New York.
Light-house	do	Do.
Life-saving station	do	Do.
Do	Oak Island, Long Island	Do.
Do	Gilgo, Long Island	Do.
Do	Jones Beach, Long Island	Do.
Do	Zachs Inlet, Long Island	Do.
Do	Short Beach, Long Island	Do.
Do	Point Lookout, Long Island	Do.
Do	Long Beach, Long Island	Do.
Do	Rockaway Point, Long Island	Do.
Do	do	Do.
Marine office	Sandy Hook	New Jersey.
Light-house	Navesink	Do.
Life-saving station	Seabright	Do.
Do	Monmouth Beach	Do.
Do	Long Branch	Do.
Do	Deal	Do.
Do	Shark River	Do.
Do	Spring Lake	Do.
Do	Squan Beach	Do.
Do	Bay Head	Do.
Do	Mantoloking	Do.
Do	Chadwick	Do.
Do	Toms River	Do.
Do	Island Beach	Do.
Do	Cedar Creek	Do.
Do	Forked River	Do.
Do	Barnegat	Do.
Coast signal station	do	Do.
Life-saving station	Loveladies Island	Do.
Do	Harveys Cedars	Do.
Do	Ship Bottom	Do.
Do	Long Beach	Do.
Do	Bonds	Do.
Light-house	Tucker Island	Do.
Life-saving station	Little Egg	Do.
Do	Little Beach	Do.
Do	Brigantine	Do.
Do	South Brigantine	Do.
Do	Atlantic City	Do.
Do	Absecon	Do.
Do	Great Egg	Do.
Do	Ocean City	Do.
Do	Pecks Beach	Do.
Do	Corson Inlet	Do.
Do	Sea Isle City	Do.
Do	Townsend Inlet	Do.
Do	Avalon	Do.
Do	Tathams	Do.
Do	Hereford Inlet	Do.
Do	Holly Beach	Do.
Do	Turtle Gut	Do.
Do	Cold Spring	Do.
Do	Cape May	Do.
Light-house	Cape Henlopen	Delaware.
Coast signal station	do	Do.
Life-saving station	do	Do.
Do	Rehoboth Beach	Do.
Do	Indian River Inlet	Do.
Do	Fenwick Island	Do.
Light-house	do	Do.

Station.	Location.	State.
Life-saving station	Isle of Wight	Maryland.
Do	Ocean City	Do.
Do	North Beach	Do.
Do	Green Run Inlet	Do.
Do	Popes Island	Virginia.
Light-house	Assateague	Do.
Life-saving station	do	Do.
Do	Wallops Beach	Do.
Do	Metomkin Inlet	Do.
Do	Wachapreague	Do.
Do	Parramore Beach	Do.
Light-house	Hog Island	Do.
Life-saving station	do	Do.
Do	Cobb Island	Do.
Do	Smith Island	Do.
Do	Cape Henry	Do.
Light-house	do	Do.
Coast signal station	do	Do.
Weather Bureau	do	Do.
Life-saving station	Seatack	Do.
Do	Dam Neck Mills	Do.
Do	Little Island	Do.
Do	False Cape	Do.
Do	Wash Woods	North Carolina.
Do	Currituck Inlet	Do.
Do	Whales Head	Do.
Light-house	Currituck Beach	Do.
Life-saving station	Poyners Hill	Do.
Do	Caffeys Inlet	Do.
Do	Paul Gamiels Hill	Do.
Weather Bureau	Kitty Hawk	Do.
Life-saving station	do	Do.
Do	Kill Devil Hills	Do.
Do	Nags Head	Do.
Do	Bodie Island	Do.
Light-house	do	Do.
Life-saving station	Oregon Inlet	Do.
Do	Pea Island	Do.
Do	New Inlet	Do.
Do	Chicamacomico	Do.
Do	Gull Shoal	Do.
Do	Little Kinnakeet	Do.
Do	Big Kinnakeet	Do.
Light-house	Cape Hatteras	Do.
Life-saving station	do	Do.
Do	Creeds Hill	Do.
Do	Durants	Do.
Weather Bureau	Hatteras Inlet	Do.
Coast signal station	do	Do.
Life-saving station	Ocracoke	Do.
Light-house	Cape Lookout	Do.
Coast signal station	do	Do.
Do	Carolina Beach	Do.
Do	Georgetown Light	South Carolina.
Life-saving station	Sullivans Island	Do.
Coast signal station	Morris Island	Do.
Light-house	Charleston Light	Do.
Do	Hilton Head	Do.
Coast signal station	do	Do.
Do	Tybee Island	Georgia.
Do	St. Simons Island	Do.

Station.	Location.	State.
Light-house	Amelia Island Light	Florida.
Coast signal station	Mount Cornelia (mouth of St. Johns River)	Do.
Light-house	St. Augustine	Do.
Do	Cape Canaveral	Do.
Coast signal station	do	Do.
Light-house	Jupiter	Do.
Weather Bureau	do	Do.
Coast signal station	do	Do.
Do	Cape Florida	Do.
Do	Key West	Do.
Do	Dry Tortugas	Do.
Light-house	Fort Jefferson, Dry Tortugas	Do.
Do	Sanibel Island	Do.
Coast signal station	do	Do.
Light-house	Egmont Key	Do.
Coast signal station	do	Do.
Do	Santa Rosa Island	Do.
Do	U. S. Navy-Yard, Pensacola	Do.
Do	Mobile Point, Fort Morgan	Alabama.
Light-house	Sand Island	Do.
Do	Ship Island Light	Mississippi.
Coast signal station	Port Eads	Louisiana.
Light-house	South Pass Light	Do.
Life-saving station	Sabine Pass	Texas.
Coast signal station	Galveston (south limit of city)	Do.
Life-saving station	Oak Island	North Carolina.
Do	Galveston	Texas.
Coast signal station	Lake Worth Settlement, West Palm Beach	Florida.

139 Life-saving Stations.

50 Lighthouses.

7 Weather Bureau Stations, and the marine office at Sandy Hook, N. Y.

The crews at the coast signal stations consisted of one chief quartermaster, three quartermasters of the second class, and one landsman. At several of the more important stations, an extra telegraph operator, rated as quartermaster of the second class, was allowed. The men were armed with rifles, and were at all times under regular Navy discipline as to watches and drills and as to all matters affecting the efficiency and health of the men.

Routine daily reports were made over the wires to district officers, and by them to the general headquarters, and local tests of the wires were made at the beginning of each watch. Inspections were made by district officers at least once each month and reports made to general headquarters.

Arrangements were made with the telegraph companies to clear the wires when warned, so that the Department could have direct communication with any of the stations, and several experiments tried during the summer demonstrated that this was

entirely feasible and took but little time; the wires were cleared between Washington and Miami, Florida, in one-half hour and the two coast signal offices put in direct communication; the same time was taken for Jacksonville, Florida. In this connection it is of interest to note that a message was sent from the Department to the Princeton, off Cape Henlopen, using the ordinary business routes, and an answer received, in twenty-two minutes; the message ordered the Princeton to the Washington yard, and the answer gave the time that she would get under way. Five minutes after she passed in the Delaware Capes the Bureau of Navigation was advised of the fact.

The service stood all the tests to which it was put; the non-appearance of an enemy is the only excuse that can be offered for not reporting one during the entire war; but as long as the Northern Patrol Squadron was kept off the coast, the stations kept the Department in touch with the different vessels, and the letters on file in the Department are evidence that the stations proved of value to several of the navy yards, keeping them advised of the movements of the vessels, and enabling the commandants to anticipate work by a number of hours. They also proved of great value to several departments of the Army by keeping them in close touch with the hospital and supply ships and transports, in many instances receiving and sending all the messages from the transports to the different camps and to Washington. This work could have been expedited and made more general if there had been signalmen aboard all the ships under control of the Army.

The means of communication from the stations to any point on beaches or inland were in every way satisfactory, and are capable of being made perfect at a very small cost but the problem of off-shore communication still requires considerable study; the shapes which were hurriedly designed did not prove satisfactory, except as a designating mark for the stations; they were too heavy for anything but slow, tedious work, and yet were so light in construction that the high winds soon put them out of commission. At distances beyond flag range, the shapes were often apparently distorted (owing, no doubt, to atmospheric peculiarities), and impossible to read.

The Navy signal-book was not issued, and all signals by flag-hoist had to be confined to the International Code, although the

men were drilled daily in reading the Navy Code flags, and provision was made for receiving confidential messages in this code, and for forwarding the numbers to Washington by telegraph.

Very pistols and stars were not issued, but the stations were well supplied with rockets, to be used in connection with a code that was gotten up to provide for emergencies; and all hands were well drilled in the use of the Very Code, and could have received and forwarded any message sent in that way.

The question of an improvised Ardois outfit gave considerable trouble, owing to the limited range of visibility of the best oil lanterns that could be bought; but this difficulty was successfully overcome at Fire Island by using acetylene gas in lamps with specially constructed burners; the small hooded pilot flames in these lamps were lit electrically by means of a spark coil, and the supply of acetylene to the three double burners grouped around the pilot flame was controlled by magnets and dry batteries; it was possible to signal more rapidly with this outfit than with those installed on the ships, as there was never any necessity of waiting for the glow of the carbon filaments to die out. Experiments proved that the lamps could be read at a distance of nine miles. Full drawings and specifications have been filed in the office of Naval Intelligence, Washington, D. C.

Carrier-pigeons were not used for the reason that it takes time to train them, and it was not considered advisable to go to the expense of installing cotes. Events moved so swiftly that when we got around to the question of pigeons, Cervera's fleet had been cooped up in the harbor of Santiago. Then came the destruction of this fleet, and the actual necessity of the coast signal service as part of the scheme of national defense against Spain became unnecessary.

Undoubtedly the most valuable lessons derived from the establishment of the service, are not only the determination of the proper localities for the stations, but the intimate knowledge gained in regard to the splendid chain of stations under the superintendent of the Life-saving Service, which puts the entire control of the beaches in the hands of one man in Washington and the knowledge gained in regard to the Weather Bureau and Lighthouse Services and their electrical connections.

This country is now in a position to establish and maintain an excellent coast signal service without the expenditure of much more money than is already provided for by law. In closing,

I do not think it amiss to quote the recommendations given in the report of the Superintendent of the Coast Signal Service to the Secretary of the Navy, all of which were carefully discussed and gone over before being embodied in the report. The suggestions are as follows:

(1) That each life-saving station should be made a Coast Signal station, for the reason that they are all connected (or can be readily connected) with each other by telephone (with offsets to the general telephone or telegraph systems of the country at convenient points) and their system of the patrol of the beach places almost the entire coast line under constant observation. Moreover, the men in this service are trained to see everything that floats within the range of vision, are trustworthy and well disciplined, and are already excellent signalmen with the international code. A knowledge of the "wig-wag" code and the navy night signals would perfect them for the purposes intended. A law should be enacted enabling the President to keep this service in commission during June and July, whenever the public interests demand it, and without special legislation.

(2) That each Weather Bureau station should be made a Coast Signal Service station, for the reason that the observers are trained signalmen with the international code, their stations are exceptionally situated for the purposes intended, and are all connected by wire with the general telegraph systems of the country.

(3) That the light-houses so situated as to fill in the gaps between the life-saving stations and the Weather Bureau stations be made Coast Signal Service stations, for the reason that it is possible at moderate expense to provide them with telegraph or telephone connections. Many of these connections have been made.

(4) That permanent Coast Signal Service stations be established at Monhegan Island (when connected with the mainland by cable); Rockport (Cape Ann), Mass.; Highland Lights (Cape Cod), Mass.; Montauk Point, N. Y.; Fire Island, N. Y.; Sandy Hook, N. J.; Barnegat, N. J.; Cape Henlopen, Del.; Cape Henry, Va.; Morris Island, S. C.; Tybee Island, Ga.; Palm Beach, Fla.; Fowey Rock, Fla.; and Sand Island, Fla., for the reason that these points have been found to be important for observation.

(5) That at each of the stations suggested in the four paragraphs above, a four-armed semaphore apparatus and an acetylene gas "Ardois" system be installed, for the reason that these seem to be the best fixed mechanical appliances to meet the requirements of day and night signaling. Also that all stations be provided with "wig-wag" flags, international code signals, and "Very" pistols.

(6) That for use in time of war, a special signal code be prepared and furnished to all the stations of the Coast Signal Service, conforming to the navy code, and using the navy numeral flags and the "Very" pistols, for the reason that, although the international code is ample for communication in time of peace, its universal use makes it of no value when

secrecy is necessary, and a code should be employed in war times which could only be read by those who have been furnished with it.

(7) That experiments be made for the purpose of training homing pigeons in connection with coast signaling, for the reason that they offer a solution of the problem of communication with vessels in the offshore patrol fleet. These vessels would most probably operate in districts having established bases, and at such a distance from the coast and from the inshore patrol that visual signaling would be impossible. A homing-pigeon service cannot be improvised and be of any real value; the birds must be systematically and patiently trained for a year or two, not only to equip the cotes with trained carriers for that locality, but to furnish a stock with sea-bred breeders. Experimental cotes should be located at the bases of Naval Coast Defense districts, a small vessel provided with a carrier-pigeon outfit, and an officer detailed to develop this means of communication and superintend the systematic training of the birds. Unless this is done with intelligence and thoroughness for at least a year it would be useless to rely upon it at all.

Such a system could be very economically inaugurated, and could be maintained at a comparatively slight cost. A simple routine of drills, exercises and reports, based upon our recent experiences, could be readily put into operation, and small rewards or appropriate ratings would stimulate proficiency. In times of peace such a service would be of constant convenience to this Department and to the maritime interests of the country, and the constant practice would prepare the men for the emergencies of war. Attention is called to the fact that every other maritime nation has such a system, generally much more elaborate than the one herein proposed, organized by and operated under its naval or maritime department. I regard it as most essential to the naval and commercial interests of the United States.

The part played by the Naval Militia in this service has met with deservedly high praise, and the men are well adapted to the service. Any scheme for the establishment of a permanent service should take into consideration the possibility of drawing on the service for deep-sea cruising, replacing the crews with Naval Militia.

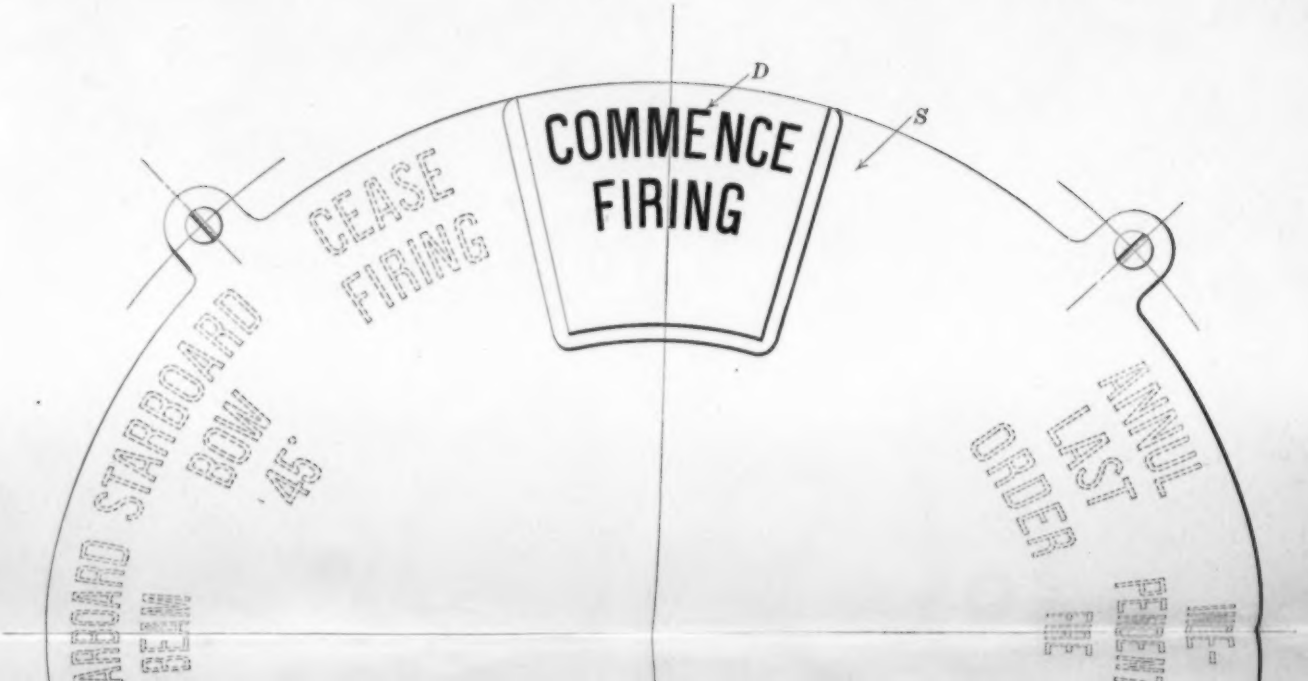
D
S
COMMENCE FIRING
CEASE FIRING
STANDARD BOW 45°
STANDARD BEAM
FINAL LAST ORDER
FINAL LAST ORDER

Fig. 1.
DIAL AND SCREEN.
Front View.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

ELECTRO-MECHANICAL BATTLE ORDER TELEGRAPH.

Proposed by LIEUT.-COMD'R SEATON SCHROEDER, U. S. N.

DIAL AND SCREEN.

An instrument of the following description is installed at the sending and at each receiving station. They all work in unison, being actuated by the same current; and their functioning is not affected by moderate variations in the strength of the current, the sole office of the current being to excite an electro-magnet at each station.

A dial, *D*, of convenient size, marked in sectors, is made to revolve behind a screen, *S*, of corresponding size, in which a sector is cut away so that only one sector of the dial will be visible at a time. A battle order is marked upon each sector of the dial.

The revolution of the dial is accomplished by means of an electro-magnet, *M*, and a toothed wheel, *W*, rigidly connected with the dial and revolving upon the same shaft. The armature of the magnet is connected by a rod to a radial bar, *B*, which is loose upon the shaft of the toothed wheel but which engages the teeth by a spring pawl.

When the current is admitted to the magnet it causes the radial bar to pull the wheel through a portion of a revolution, enough to bring the next sector of the dial into view. The current being shut off, a spring pulls the armature up and the radial bar back into position ready to pull the wheel through another sector when the current shall be turned on again; so that each display requires one or more positive actions.

A strong spring catch, *C*, engaging the teeth holds the toothed wheel in each position successively to which it is brought, preventing it from turning back; as it presses on the back of the

next tooth (which is struck with the same radius), this catch also acts as a friction brake and steadies the wheel and holds it from slipping too far forward. Furthermore, it will push the dial back the short excess of distance that the armature should carry it forward, such excess being required to allow for any dirt or foreign substance which might lodge on the pole or come between it and the armature.

The mechanism is the same for all the dials, both sending and receiving, unless the automatic stop (described later) is attached to the sending.

The number of battle orders can be made as great as desired by increasing the size of the dial; but it is suggested that eleven will be enough, besides one blank sector, all of which could be plainly marked on a disc ten inches in diameter.

Interrupter.

A simple way to interrupt the current is by pulsating with a push-button in the conning-tower, or other sending station. But in the excitement of battle the button might be nervously pushed the required number of times in too rapid succession to excite properly all the magnets, and some might act and others not. To prevent this, a make-and-break wheel or interrupter is introduced in the circuit, which is caused to revolve at a fairly uniform rate of speed by a clockwork on its rear face; this wheel is divided into any convenient even number of sectors, one-third of the surface of each sector being insulated, so that when the button is pushed or a switch turned on, as the wheel revolves the circuit will be closed and broken alternately once for each sector of the dial, thus displaying each in turn. When the desired order is displayed, the button or switch is released by the sender.

The number of sectors of the interrupter should bear such relation to the speed of the clock train as to produce the desired length of contact on each sector. This would best be determined by experiment; if it be one second for each sector, the maximum time that could be required for any order would be 12 seconds. It seems probable that a perfectly certain operation could be effected in half a second for each sector, but this would require inconveniently precise work in releasing the switch.

The *break* surface of each sector is half the size of the *make* surface, as the actual work to be done during the *break* is much

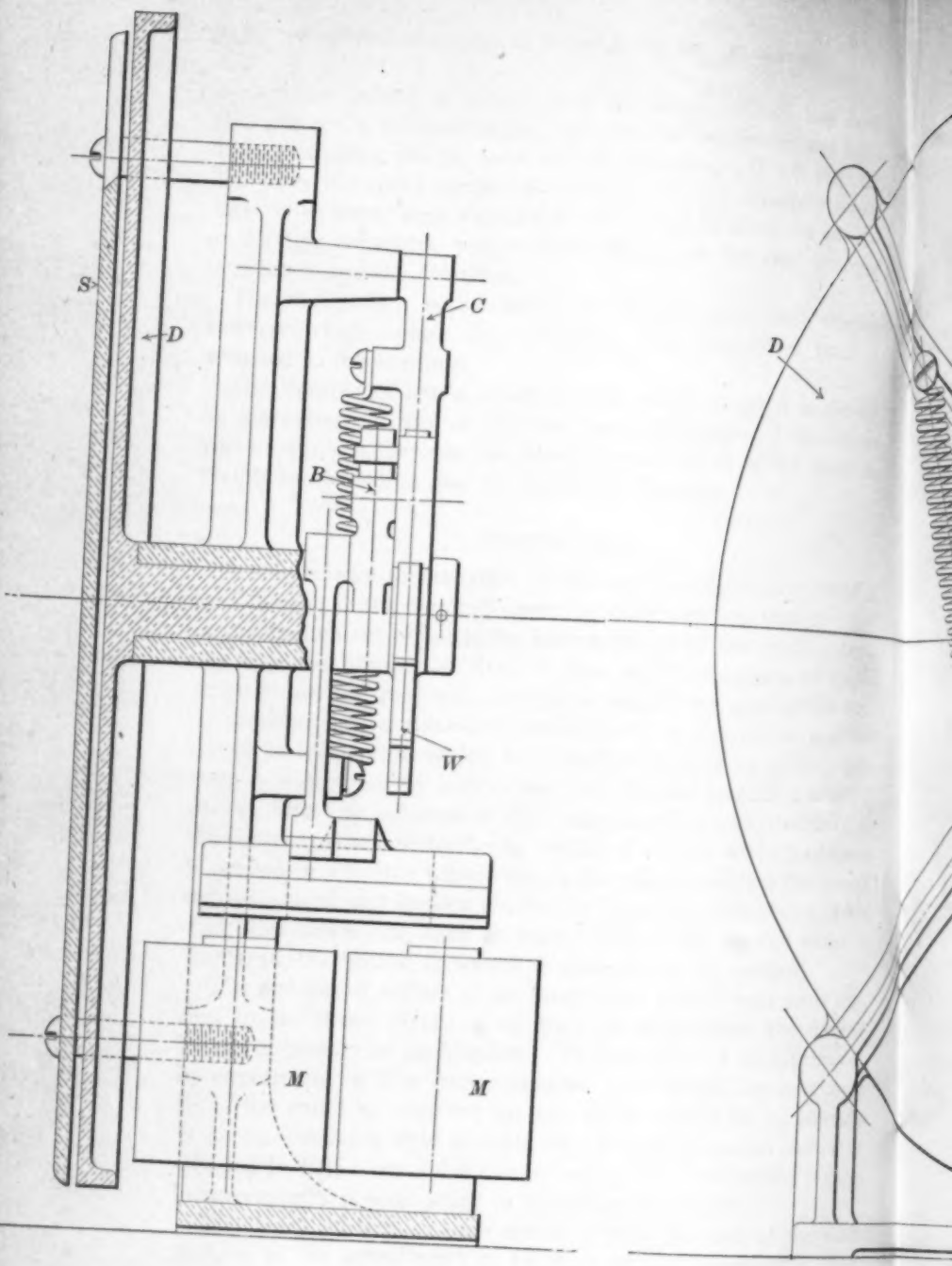


FIG. 2.

DIAL AND SCREEN.

Side View.

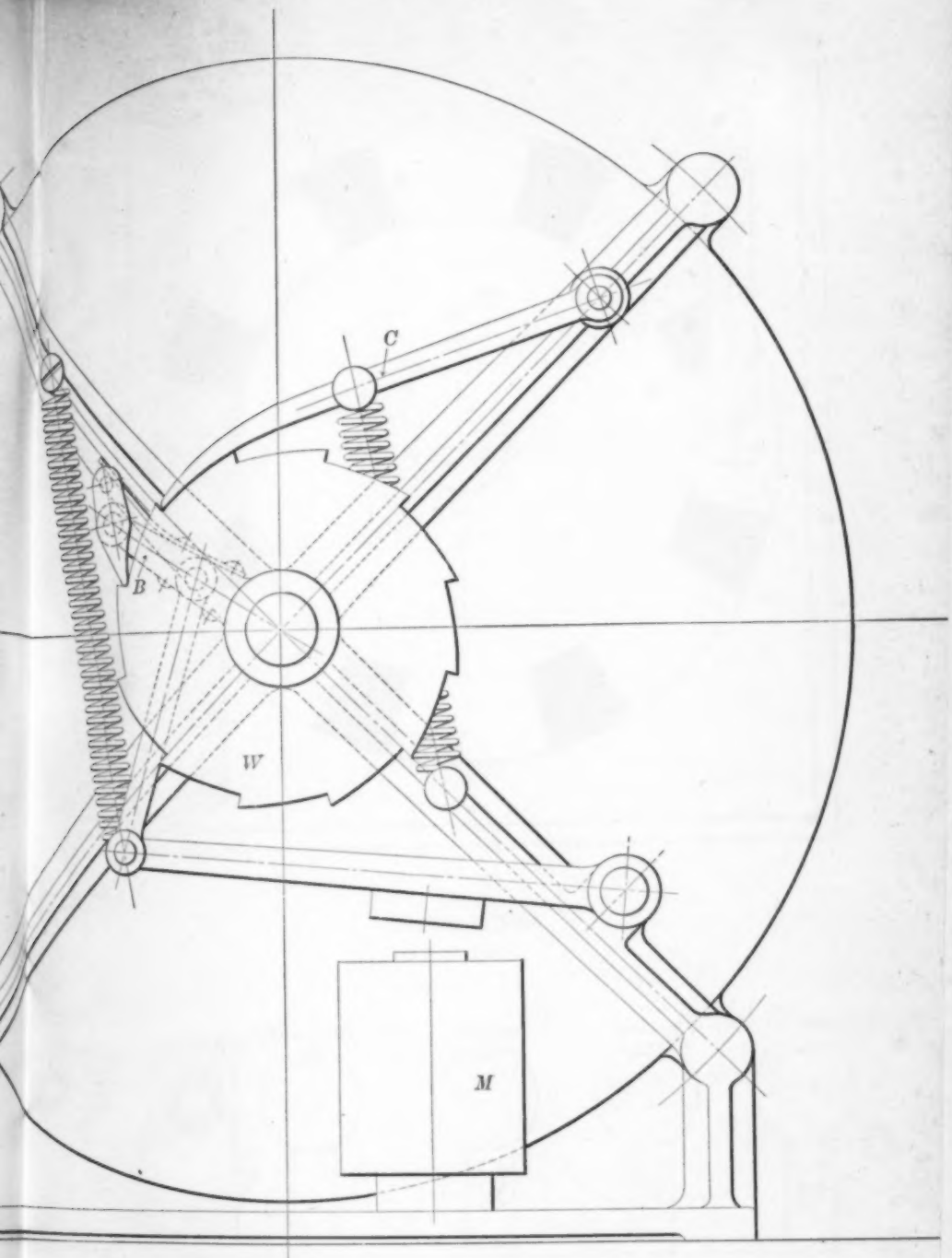


FIG. 3.
DIAL.
Rear View.

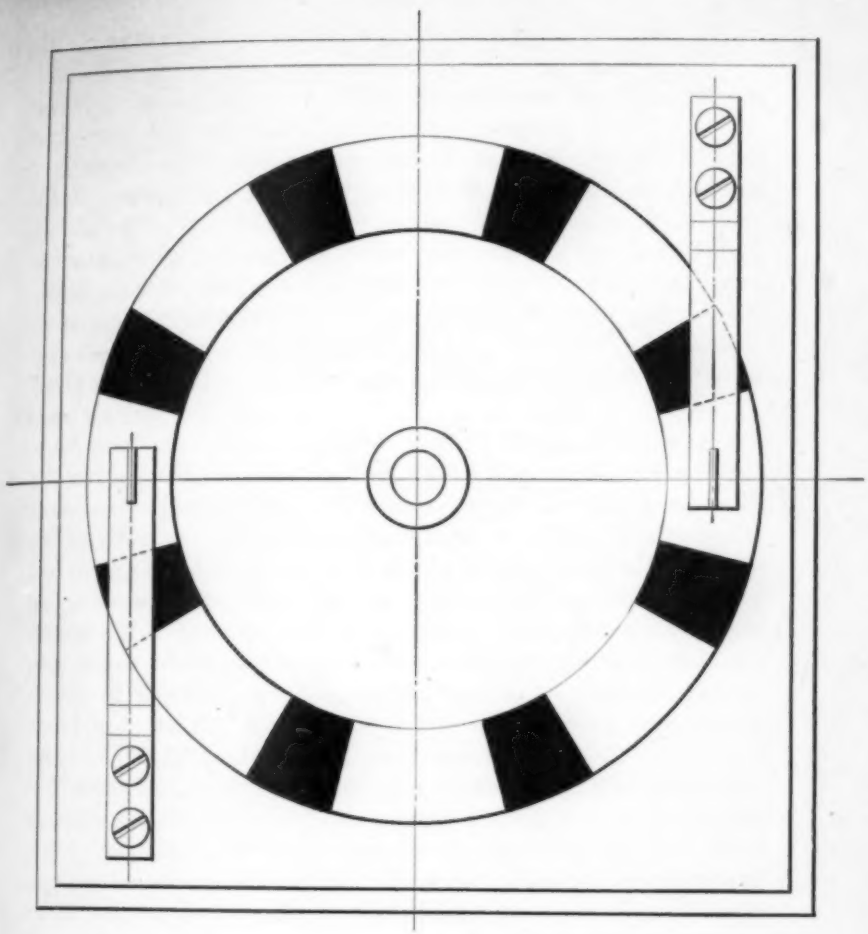


FIG. 4.
INTERRUPTER.
Front View.

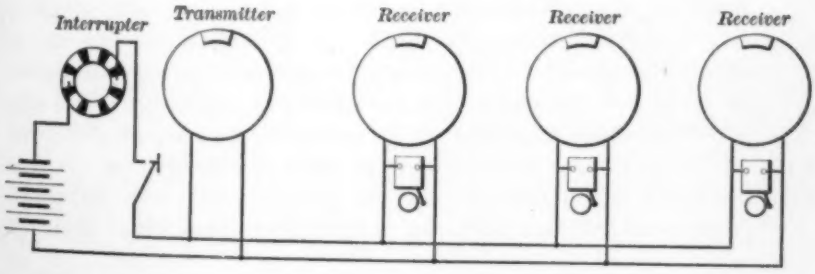


FIG. 5.
DIAGRAM OF CIRCUIT.

less than during the *make*. The current enters by one contact, and, traversing the wheel, leaves by the other.

A switch which will remain turned on until changed is preferable to a push-button, which must be kept pressed all the time, for the reason that in the event of the operator being disabled or diverted while sending an order, the use of the push-button would result in telegraphing some wrong order which happened to be momentarily displayed at the instant of disablement; while with the switch the apparatus would keep on functioning indefinitely and no order would be transmitted, which would be better than sending a wrong one.

All receiving stations and the sending station will be in the one circuit; and at each receiving station there will be a call-bell in the same circuit, which will ring whenever the circuit is closed, calling attention. At the sending station no call-bell is necessary, and there should be none, as the noise would interfere with telephone or other service. At the sending station, also, the dial should differ from the others in having small projections from each sector beyond the screen, upon which should be marked the nature of the corresponding battle orders, so that the sender could note as the desired order was approaching the display aperture and be ready to turn off the switch.

The clock train for the interrupter should be strong, with undetachable key, and designed to run only a few hours, so that at the end of the battle or test or exercise it would finally run down and not be needlessly worked. The fact of its not being wound up on any occasion would be immediately shown by the failure to operate, and the key being always in place it could be promptly wound. All working parts should be heavy and strong, and the magnets should have a vigorous reserve of power.

Circuit.

As the different stations are connected in multiple, an accident to one will not knock out all. It is recognized that when connected in this way there is no indication at the sending station that one of the stations is disabled; but that is not believed to be of equal importance to maintaining all the rest when one is disabled.

If the main should be shot away, the entire system would be paralyzed, as in the case of any mechanism; if the breakage occurred at the instant of sending an order a wrong one might

be displayed, but the fact would be known at the sending station, as the same order would remain displayed there. This appears to be the only contingency in which a wrong order could be given, and it is a remote one.

The possibility is contemplated of having one main for the starboard battery and one for the port, with plugs to put in to connect either or both; but it is recognized that any such subdivision detracts just that much from the simplicity aimed at, and may not be of any utility.

The general system is applicable for a range telegraph; it is suggested that the indications commence at 1000 yards and extend in increments of 200 yards to 3000. Within 1000 yards a knowledge of the range is not necessary, and the action would also be too hot to attend to it; beyond 3000 yards the range is not accurately obtainable. As decreasing ranges are apt to vary more rapidly than increasing, the maximum range should be the first in order of arrival at the display aperture, so as to require the minimum interval for telegraphing a decreasing range.

The system may also be applied to a steering telegraph. With several telegraph circuits installed on this system (battle order, range and steering), only one interrupter would be needed; and orders could be sent simultaneously through all the circuits, the only proviso being that the current be strong enough to properly excite the entire number of magnets.

Automatic Stop.

As it may be objected that in time of battle the sender should not be called upon to watch the operation of the instrument, for possibly 12 seconds, in order to shut off when the desired order is displayed, an attachment is suggested for the sending instrument by means of which the sender needs only to put a plug into a socket in the periphery of the dial and then let it operate automatically. This, of course, adds to the amount of mechanism and detracts correspondingly from the simplicity, though not to a prohibitory extent.

Two insulated terminals are secured to the front face of the screen at the sending station. The right-hand one, *R*, constitutes a bracket for a small shaft, the upper end of which terminates in a bell-crank lever, *O*. The left end of the bell-crank presses against a stud or knife switch on the left terminal, *L*,

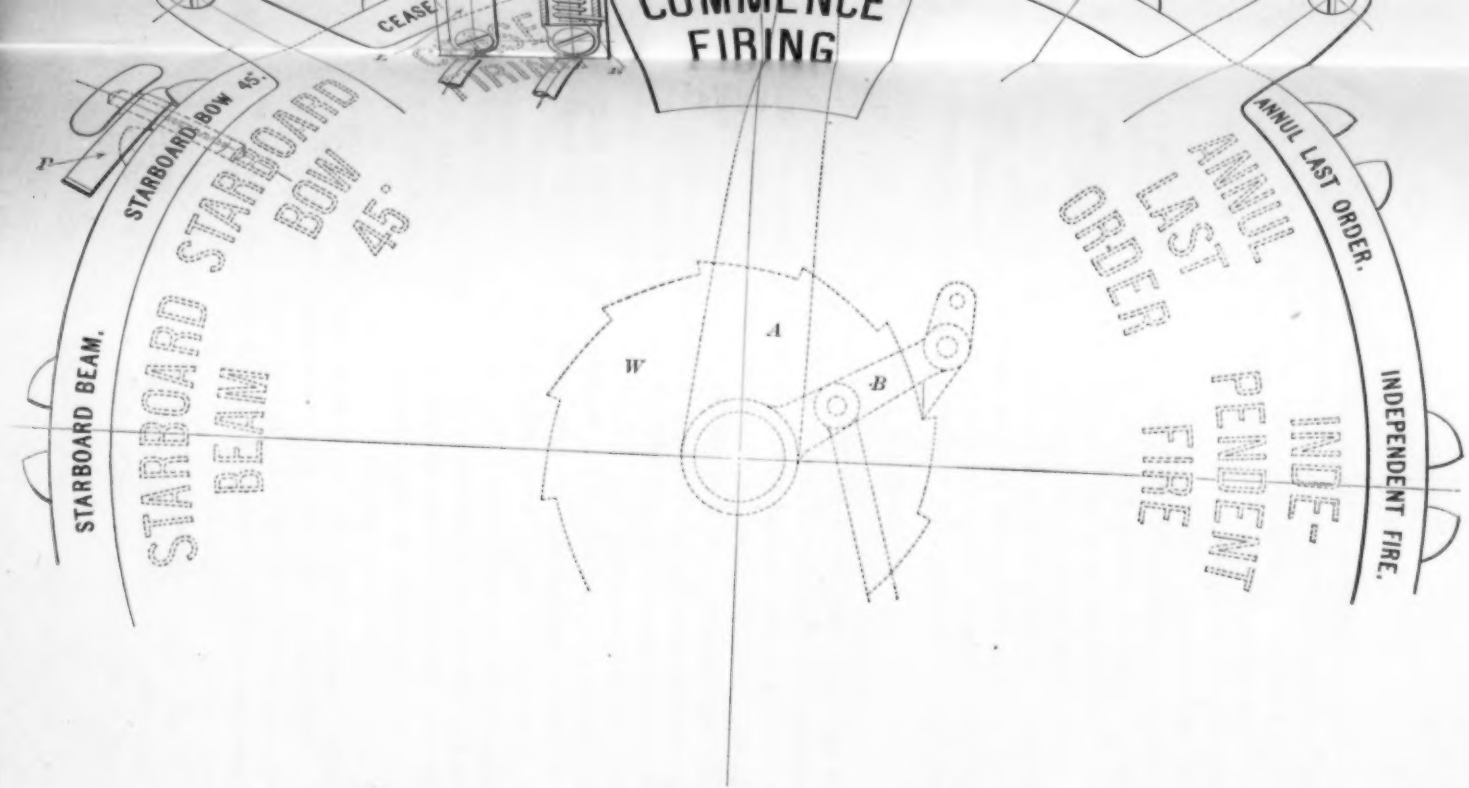
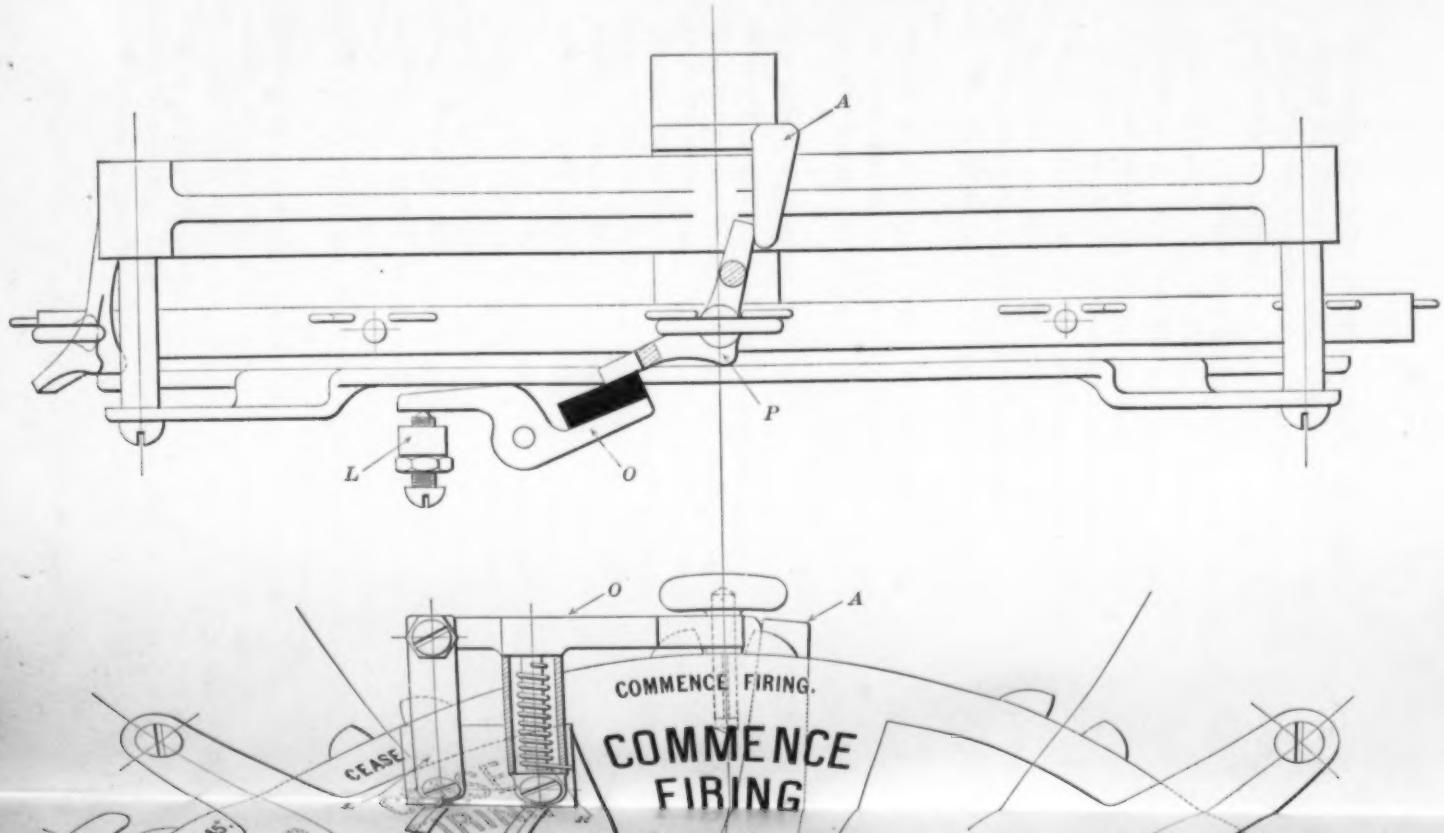


FIG. 6.
FRONT VIEW.

FIG. 7.

PLAN VIEW.



being held in that position by a coiled spring, and completing the circuit. In the periphery of the dial there is a small socket bored in each sector; the shaft of the second bell-crank, *P*, may be plugged into any one of these sockets. An upper arm, *A*, is fashioned on the hub of the radial bar, which, during the reciprocating movements of the bar, moves back and forth through a small arc around the center of the dial.

To stop the dial at any sector, plug the bell-crank, *P*, into the socket of that sector. When that sector reaches the display aperture the bell-cranks will have the relative positions shown in the drawing; the radial bar being released from the magnet and returning to its upper position, its upper arm, *A*, takes on the bell-crank, *P*, breaking the contact of the first bell-crank, *O*, breaking the circuit, and stopping the entire system.

Wishing to send another order; take another bell-crank, *P*, plug it in where desired, and take out the one previously plugged in. The spring around the shaft of the first bell-crank, *O*, turns it back to the original position, closing the circuit again through the left terminal, and starting the system. Guide studs on either side of each socket, together with the peculiar elbow of the bell-crank, compel entering the bell-crank properly; the operation will be facilitated by remembering that the larger, round arm goes to the rear between the studs.

As indicated in the drawing, the arms of the frame and the lugs of the screen for a sending dial with automatic stop are longer than for an ordinary dial, in order to leave room for the bell-crank plug to pass.

The wires indicated at the binding posts are drawn simply to illustrate the circuit. Insulated copper strips on the screen would preferably lead the current to and from the base of the instrument. For the purpose of this attachment, the entire current of the system must pass through the terminals on the screen. As the radial bar has more work to perform, the spring which returns it to the upper position must be strong, and also the magnet; though in all the instruments the reserve power should be more than enough for any such slight increase of weight.

With this attachment in use the speed of revolution of the dial may be much greater; because there is no doubt of the electricity doing its work fast enough, the only limitation being the ability of the sender to seize the right instant to shut off when the

automatic stop is not used. This increase of speed would leave it expedient to increase the number of displays if desired.

In manufacture, no doubt a few changes will be found necessary in mechanical details. One instrument was ordered made for experiment at the New York Navy Yard, but it was found that the brass revolving dial plate was too heavy, and the work was stopped. The substitution of a light tin dial would probably remove that difficulty.

It will be observed that with this instrument one signal is eclipsed before another can be made, so that no confusion or uncertainty can arise as to which was the last order.

Desirable orders other than those suggested in the drawing would include " use full charges," " use reduced charges," " use common shell," " use A. P. shell," " use Shrapnel "; while those given, such as " starboard bow," could be given a second meaning, as " watch for torpedo-boat on starboard bow," etc.

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THE AMERICAN INTEROCEANIC CANAL.

A STUDY OF THE COMMERCIAL, NAVAL AND POLITICAL CONDITIONS.

By Captain C. H. STOCKTON, U. S. N.,
President of the Naval War College.

The completion of a Ship Canal across the Central American isthmus, connecting the Atlantic and Pacific oceans, will undoubtedly mark an epoch in the history of the civilized world. Not only will this be true from the commercial point of view, but the international changes and questions involved are of such a nature, that the words of an English publicist are not too extravagant when he says that it makes "The possibilities of the future so rich and so varied that even the political imagination quails before them."

With the political and commercial results to come from the construction of this new water highway of the world are also naval and military questions of great interest to all maritime countries, but of especial importance to the United States, presenting possibilities that justly claim the attention of officers of the naval service as well as of the statesmen of the country.

To the Navy of the United States the subject of an American interoceanic canal has always been a matter of great interest. Its earliest and most ardent advocates have been members of our profession, and the most indefatigable and persistent explorers and surveyors of the various proposed routes have been officers and men of the Navy.

The effect of the completion and use of the American Canal will differ from that of the Suez Canal, among other things, from the fact that the Suez Canal caused to an extent an alteration,

with a consequent shortening and quickening, of trade-routes already in long use, between countries thickly populated, whose staple products were articles of trade and consumption for centuries. The American Canal, on the other hand, connecting the two great oceans of the world, brings direct and central communication by water with the great Pacific, whose existence is a matter of comparatively recent knowledge, and whose countries, to a great extent, of modern discovery and settlement by civilized peoples, are not thickly populated and but partially developed. While the trade of Suez will undoubtedly continue to increase, it will by a steady process; while the trade of the American Canal should increase with great strides, accompanied as it will be with the increased population and development of the west coast of America, with the growth of United Australasia, and with the establishment of stability and trade relations in our new insular possessions in the Pacific and the East, as well as in China and Japan.

With the greatly increased seaborne trade between our Atlantic and Pacific slopes and our insular territory will surely come an increase of shipping under the American flag, mainly of steamers for freight purposes, and the development of the American freight or cargo steamer should follow. With the great increase in number of vessels under our flag, constructed at first for our domestic trade, should we not expect that economy in construction and management will follow to such an extent that we can compete successfully for a large share of the carrying trade of the world?

With regard to the saving in time and distance that will follow by the use of the American Canal, an examination of the map will show this the most effectively. It is perhaps also unnecessary to refer to the avoidance of the long and stormy sea-route by the way of Cape Horn or the Strait of Magellan, or to speak of the natural disadvantages presented in the carrying of freight with economy over the three mountainous ridges between the Atlantic and Pacific coasts. These and troublesome transshipments will be avoided by the Canal, and the world can be circumnavigated by the aid of this Canal and that of Suez north of the equator and in regions of moderate weather and climate.

It is proposed in this article, in view of the partial construction of two interoceanic canals at Nicaragua and Panama, and of the

manifest desire on the part of our legislators and people to have an interoceanic canal, to make a study of the conditions that exist and will be affected by the creation of this new great trade route.

The examination will not be confined to the commercial and strategical aspects of this question alone but will include the international relations and policy to be affected thereby so far as these can be surmised at the present day.

The three plans that of late years have been presented for the solution of the question of ship transit to the Pacific from the mid-Atlantic are:

1st. The construction of an interoceanic canal across the isthmus of Panama.

2d. The construction of an interoceanic canal and water-route by the way of Nicaragua; and

3d. The construction of an interoceanic ship railway across the isthmus of Tehuantepec.

The first plan, that of the Panama Canal, upon which work was abandoned in 1889, to be resumed in 1894, is under the control of a French Company, the successor of the one originally formed by De Lesseps.

Ground was broken for this canal in 1882 by the original French Company after the completion of the preliminary work and surveys. From an examination of the various reports and to an extent from a personal examination, it is not unfair to assume that no more than one-third of the work required is completed. The prosecution of the work by the present company is not such as to expect any material change from that proportion of completed work for some time.

Of the Nicaragua Canal and route it may be briefly stated that the route proposed to be followed by this Canal is the final result of many surveys carried on at various times and places in Central America and Mexico by officers of the Navy and under the auspices of the United States Government, and that this route is the one most favored by our people and government. The concession given to a company regularly chartered by the Congress of the United States, by the Government of Nicaragua, resulted in considerable work being done by that company, but less than that done at Panama. The financial suspension of this company in 1893 was, however, followed by a cessation of all work of con-

struction upon the enterprise. Its resumption under the auspices of the United States Government is a subject of investigation and legislation at the present time.

The third and last plan for interoceanic transit was that proposed by the late Captain Eads for a ship railway across the isthmus of Tehuantepec in Mexico. The concession for this railway was granted by the Mexican Government in terms which make it virtually a Mexican affair.

This scheme of transit is so foreign to the ordinary methods of ship navigation that although in a limited or occasional way it may be made an engineering reality and success, it does not seem to be ever likely to become a commercial success or to solve the question of interoceanic transit. In fact, the death of the promoter, upon whose reputation, gained in other undertakings, this scheme seemed to rest, has proven fatal to its progress.

The question of the comparative value of the routes by Panama and Nicaragua from an engineering point of view being a matter of present investigation and report by a commission of competent experts duly appointed in accordance with law by the President of the United States, renders unnecessary any discussion of the matter from this point of view by the writer.

It can be said, however, that both routes have their engineering difficulties. The route by Panama has to deal with such questions as the diversion of the Chagres river and its flood, the water-supply for the locks now proposed, and the permanence of the cut at Culebra; while in turn the Nicaragua route presents such problems as the Ochoa dam, the deep-water harbor at Greytown, and the more frequent earthquakes of this region. Engineering problems seem, however, in these days, to be made only to be solved, and it is doubtful whether any of these mentioned are beyond the skill and capacity of the engineers of the twentieth century.

The distances, however, between Greytown or San Juan del Norte, and Colon in the Caribbean; and Brito and Panama in the Pacific, being comparatively small, the conditions that will apply to one canal and its termini will also apply practically to the other, so that it will not be necessary, so far as this discussion is concerned, to follow but one route or one set of terminal ports. Colon and Panama being at present the converging and diverg-

ing points of the trans-isthmian trade already existing will be the ones naturally followed in each ocean.

All of the trade-routes now existing from the east coast of America, from Europe and from the Atlantic generally to the Pacific enter the Caribbean by comparatively narrow channels and passing for a greater or less distance through that sea converge at Colon. These routes are continued, after transshipment by rail from Panama on the Pacific side, by coastwise routes north and south, as at present there are no steamer lines or regular sailing routes that radiate into the broad expanse of the Pacific.

The importance of the waters and approaches of the Gulf of Mexico and the Caribbean Sea in a military sense can be seen at once and will be a subject of detailed examination later.

The present trade-routes by water to the Pacific from the Atlantic are either those by the way of Cape Horn and the Straits of Magellan or those by the way of Colon with a transshipment at the isthmus of Panama. The other routes from ocean to ocean are those by land represented by the transcontinental lines of railway of the United States and Canada, or those partly land railway and partly water, that go by the way of the Gulf and hence overland through Texas or Louisiana, or still others which utilizing the Great Lakes go overland from two or more ports on the western basin of Lake Superior.

The present direct steamer routes from the United States to Colon can be reduced to two: The first from the northern ports of the United States by the way of the Bahamas, the Windward Passage and thence across the Caribbean to Colon. The second route is from the Mississippi and the Gulf ports, across the Gulf of Mexico to and through the Yucatan Channel, and thence along the coast of the western Caribbean to Colon. Besides these routes, a route to Europe and the North Atlantic ports is followed by low-powered steamers and at times by the New York steamers from Colon by the way of theYucatan Channel and the Straits of Florida. In this way the Gulf Stream is utilized and the trade-winds minimized, while Europe-bound steamers of small coal capacity will have our Atlantic coaling ports within easy reach when necessary.

The European routes to the Central American isthmus go across the Atlantic to and through the Virgin group or the

Windward Islands, and then along the length of the Caribbean. The Azores and Madeira afford ports of call *en route*, using either as vessels come from the north or south of Europe.

Sailing vessels from Europe bound for the same destination, as a rule, run into the Trades, crossing the different parallels of latitude at varying points according to the season until 20° N. latitude is reached, when a due-west course is followed to the isthmus of Panama.

The steamer routes from Panama, as already stated, run coastwise north and south, to the northward reaching Central American and Mexican ports and finally San Francisco. At the latter place lines to the north as far as Alaska are to be found and to the westward are the routes to China, Japan, Siberia, our new territory of the Hawaiian Islands, Guam, the Philippines, Tahiti and Australia. The southern route reaches as far as Valparaiso in Chile and there connects with the lines going through the Straits of Magellan, or is continued by that route to Europe and eastern America. The sailing routes to and from the west coast of America, via Cape Horn, are well off-shore, approaching no islands of importance in the Pacific.

The modifications that would come to these various routes after the opening of the interoceanic Canal would be in the matter of a continuity through the canal to the Pacific Coast and the establishment of new and direct routes to Australia, eastern Asia, Hawaii, the mid-Pacific islands and the Philippines from the Atlantic by the way of the Canal.

Europe will reach western America, the mid-Pacific islands and New Zealand by the American Canal, and a rival route to that furnished by Suez will most probably be established via the Central American Canal to western Australia, eastern Asia, and the mid-Pacific islands.

As a summing up of this part of the question, I can do no better than to quote from a recent work of Mr. Archibald Colquhoun, an English authority, upon this subject. He says: "Through the Suez Canal, England has at present the advantage of the United States as regards China, Japan and Australia, by about 2700 miles. The Nicaragua Canal made, the Atlantic cities of the States will be only 1000 miles further from Hong Kong and Central China generally than Britain; 1200 to 1900 miles nearer the northern ports of China, Korea and Japan; 2700 miles

nearer the average of the western ports of South America; 1300 miles nearer Melbourne; over 3000 miles nearer New Zealand. The Canal will bring New Orleans 1000 miles and the Gulf ports from 700 to 1000 miles nearer again than New York. The Canal will place the States in touch with 500,000,000 people with whom at present they have comparatively little intercourse, namely the peoples of China, Japan, Korea, Australasia, Malaysia, Ecuador, Bolivia, Peru and Chile."

As to the articles composing the trade now existing to the Pacific from the Atlantic countries, it will be found that the Atlantic coast of North America and Europe furnish almost all of the trade coming from the Atlantic to the Pacific countries. Besides provisions, cotton and petroleum for China, Korea, and Japan are about the only raw or unmanufactured articles coming from the eastward to the Pacific. Europe and our eastern coast send such manufactured articles as wines and spirits, metals and manufactures of iron and steel, cotton, woolen, silk and linen fabrics, and wooden and earthen ware. Corn and its products are not to be found on the Pacific coast, while tobacco comes to our own coast much more from the Atlantic and Caribbean than from the Philippines.

The return trade from the Pacific countries is composed mainly of raw materials, after wines and flour are enumerated; these are such staples as wheat, wool, lumber, gold, silver and other metals, coffee, dried fruits, copra, sugar, nitrates, teas, rice, silks, strawbraids, mattings, hemp, and various other products peculiar to China and Japan.

In making this examination of the subject of trade conditions connected with the Canal, it is found that the trade to and from the West Indies will be comparatively small, there being too much similarity in the tropical and semi-tropical products of both oceans to cause much more interchange of their staple products beyond that which can be taken by vessels *en route* to and from Europe and the east coast of America bound for the Canal.

Fertilizers from the south Pacific, lumber, provisions and canned fruits and salmon from Oregon and California, teas and products from the Orient, will be exchanged in small quantities with tobacco and sugar from these countries of the Caribbean.

A trade also, but not of great moment for the immediate

future, will also spring up with the east coast of South America and the Pacific, and also between the east and west coasts of South America.

It is not my purpose to add other estimates to the many that have been formulated of the volume of trade that will go through the interoceanic Canal. No one doubts but that it will be great and rapidly growing, with eventual profit to the Canal builders, but the situation with respect to the Canal from a natural standpoint, always very important, has been so accentuated by the Spanish war and its results, that the question of commercial profit is no longer a vital one in the subject of the construction of the interoceanic Canal. It is no longer a question, either, of the economy of water transportation in comparison with that by land. The economy of each method and the time by land and water routes now come closely together; but with the freedom of a water route will come a freedom from monopoly that will tend more and more to cheaper freights to, and increased commerce between, our Atlantic and Pacific coasts. With the other countries a water route for commerce is alone possible. Besides, the economy attained in rail transportation does not continuously prevail over the entire continent of North America with its three ranges of mountain's grade to be considered and its want in many sections of profitable local trade.

In examining the trade conditions of the canal more in detail, we find, as to the Central American states, that on the west coast English and German steamers already compete with the older Pacific mail lines. These would also be tributary to the Canal. Coffee, so much a staple of Guatemala, Costa Rica, Salvador, and even western Mexico, finds in Germany the great coffee-drinking country of Europe, a large market, which in turn will be reached by the Canal. The Pacific coast line of these countries, rising rapidly to the interior highlands, is not only well suited to the growth of coffee and cocoa but also for the residence of white men. The United States, second only to Germany as a coffee-drinking country, would also afford a market for these products, a market reached principally by the use of the Canal when opened. In return for such products and also for the valuable dye and cabinet woods of the countries, would come the manufactured articles of the Atlantic States and Europe.

Immigration, never properly fostered or perhaps sincerely de-

sired in Central America, would, with the commerce, civilization and stability of government brought by the canal, come from various parts of Europe and the United States to the high, equable regions of interior Central America. The mineral development, now retarded by the poor communications and frequent revolutions of these little countries, would give a development to the mineral wealth of Central America and consequently a quick impetus to this little-known area.

The Pacific coast of Mexico is much greater in its length than that of the Gulf but its development is much retarded by its isolation. Its range of products, like its range of latitude, is greater though its communications are so bad. Coffee, chemicals, salt, dye and cabinet woods are products of this coast with possibilities of coal. The cocoa of the Pacific coast state of Chiapas is unequaled, while the coffee of Colima ranks as high as that of Mocha. Vanilla, upland rice and tobacco are found to the south of Mazatlan, while virgin forests near the coast abound in the valuable wood just referred to. Guano and phosphates, in addition to salt, are found in the Gulf of California, while on the peninsula of Lower California as well as on the opposite main land are mines of gold and silver which have been worked for years.

The United States still leads in the return trade to these countries although many of the resident merchants are English and German. San Franciso and San Diego are the two ports of California for foreign trade. The former city and port is still the great trade center of the Pacific American coast, and the cargo steamer bound for the Asiatic coast will find it not far from the great circle route from the Canal to China and Japan, and hence a convenient and advantageous port of call and coaling. The central position of San Francisco, its mild climate, magnificent harbor, extensive internal waterways and its radiating railway and steamship lines have given it a start and facilities not likely to be overcome by the ambitious cities of the neighboring states of Oregon and Washington. With an unfettered trade to the Atlantic countries will come a greater distributing trade throughout the Pacific. California is pre-eminently a great agricultural, horticultural and mineral State, manufactured articles being still of eastern origin. Coal, which is lacking as a home product, could come here via the Canal from our eastern coasts

better than from distant Australia or from the inferior mines of British Columbia and Washington.

The wheat and flour of our Pacific coast would still largely go to Europe by water, and by the Canal; other breadstuffs, canned fish and provisions, leather and tallow, and lumber would follow the same route, while in return general merchandise would come by this new water route.

Alaska, with its mineral wealth, the Aleutian Islands and the ports of Oregon, Puget Sound and British Columbia would have direct trade by, and through the canal, and freight steamer lines to and from western Asia would find profitable stopping places as just mentioned all along the coast-line.

In examining the west coast of South America we find that the western portion of Colombia only awaits the opening of the Canal to furnish its quota of profitable trade with Europe and eastern America. Ecuador already through its principal outlet—the port of Guayaquil—has extensive trade to Europe by means of German, English and other steamers, and the route by way of the Straits of Magellan. Cocoa is the principal staple, but coffee, india-rubber, cinchona and hides are also products of the country, all needed by Atlantic and European markets. Ecuador is a Pacific coast state whose products can go by water alone to a foreign market.

Peru sends its gold and silver ores and its cotton and sugar to Europe, and should share its export of hides, chemicals and wool with the Atlantic coast. A glance at the map will show how much nearer the Canal in every way will bring this part of the Pacific to New York and our east-coast ports. The narrow isthmus makes a very serious break in this trade route, the want of water continuity more than neutralizing this comparatively short distance to the United States.

Chile not only furnishes copper and breadstuffs to Europe, but also of late years sends to both Europe and the United States the nitrates, borax and precious metals from the annexed districts of Tarapaca. All of these countries of the west coast depend upon Europe and America for manufactured articles which will come by way of the Canal.

The islands of the southern Pacific furnish principally copra, sugar, cotton and tropical fruits. Copra will be a product that will pass through the canal, but when in due time the labor

question is settled in these islands other products will find their way to the wealthy and thickly populated countries of Europe and America.

New Zealand belongs to the domain of the American Canal both with respect to Europe and the United States. This British colony has much similarity in geographical formation but less in climate to the British isles. With its insular position and good harbors, rich coal deposits and agricultural and pastoral resources, it can in the future become besides a wheat and wool-growing community—a maritime and manufacturing country, and an important factor in the trade of the Canal. Now, its products are mainly wool, frozen meats, gum, flax, tallow and gold, while the imports are cotton, woolen and linen fabrics, hardware and machinery, all from Europe and the United States.

As to the Philippines, now under our own flag, there is sugar, hemp, coffee, tobacco and spices and probably gold and silver ores that are on the surface ready for us when peace and tranquility arrive. What else will be developed under our rule one can only surmise from the reports that reach us. Certainly rice can be made a product not only for export to the coasts near by but to our own coasts. The Dutch East Indies also furnish like products.

The Hawaiian islands will be exploited to the fullest extent now that they are at last American territory. Sugar will not be the only staple, nor its position as a place of call and coaling the only advantage accruing to and from these islands. Coffee is becoming of value as an article of export, its quality being excellent. Sugar, however, is the staple which will make or unmake these islands, and so far the product of the beet-root does not affect their prosperity in the world. The self-supporting capacities can be realized when it is known that after an exhaustive study the late Consul-General Haywood was able to draw up a memorandum showing that the island of Oahu alone could stand a close blockade indefinitely without suffering from want of food.

Although considerable space has been devoted to a discussion of trade-routes and the trade of various countries in connection with the Canal, no attempt will be made to give an estimate of the volume of trade that would be likely to pass through the Canal, nor will any figures be presented to show the future com-

mercial success of this trans-isthmian Canal. They would be at best conjecture. At one time the construction of the Canal hung upon the requirements of commercial interests alone, and the question of the profit arising from the trade passing through the Canal. It is believed that this stage of the history of the proposed Canal has been passed and that the construction of the Canal is required by the interests of the state and as a matter of national policy, and that though the commercial element in the Canal is still a matter of great moment it is not a vital one.

As a consequence, a further study of the future field of the Canal with a view to political and naval needs will be both interesting and important.

Let us commence with the channels by which the most direct routes from the Atlantic and Gulf ports of the United States enter the Caribbean basin, the way to the proposed Canal terminals. These channels are the Windward Passage and the Yucatan Channel, both placed off the eastern and western ends of the great island of Cuba.

In importance of geographical and strategical position with view to the Canal and the routes thereto from the United States, Cuba stands first in order of all the islands and countries of the West Indies. Its commanding position with respect to the Florida Straits and Yucatan Channel on the north and west is augmented by its position towards the Windward Passage and the channel north of Jamaica on the south and east. In addition to this must be borne in mind the position of Cuba towards the Mississippi river and valley, and all that is therein contained. It has been recognized for many years that Cuba stands in the attitude of an outer bar of the Mississippi and that the channels by which the trade of this great river reaches the sea are not those of its delta and passes but those furnished by waters of the Yucatan Channel and Straits of Florida, the outlets of the Gulf of Mexico. Recognizing this as a fact, the importance of the strategical relation borne by Havana to the Florida Straits, Cienfugos to the Yucatan Channel and Santiago and Guantanamo Bay to the Windward Passage becomes evident. These great military ports give Cuba its strategic value to the United States if it remains under the sovereignty of the United States. If it should pass to the control of a sovereignty other than that of our own, it should be one whose policy will be in unison with us.

With Cuba in our possession or sufficiently under our influence, the only other position needed by us in the Caribbean is a sufficiently good military port at or near the eastern terminal of the Canal. This terminal port, whether belonging to the Canal of Panama or that of Nicaragua, is not likely to be more than an artificial harbor or basin for coaling or necessary delay before entering or leaving the Canal. Hence, the purely military port must be looked for elsewhere. To avoid bottling up it should be exterior to the Canal. Fortunately, nearly midway between Colon and Greytown, the terminal points considered, are situated the anchorages and harbors known under the collective name of the Chiriqui lagoon. These waters were discovered by Columbus himself and the northern bay bears the name of the great Almirante. They were surveyed by Captain Barnet of the English navy in 1839, and they have frequently figured in the discussions of trans-isthmian railways and interoceanic canals.

The general rule that the deepest harbors lie alongside the highest mountains has no exception here, and the height of 6000 feet found in the most feasible mountain pass near Chiriqui lagoon banished all ideas of both canal and railway construction. The proximity, however, of the Gulf of Dulce in the Pacific and its fine harbor of Golfito has led to a grouping of these two places together and the acquisition of them both by the United States has been frequently urged. So valuable were these sites that speculators and others acquired a title, more or less valid, to great tracts of land about them. These titles are believed to have become void on account of the non-fulfillment of the conditions required in the original concessions.

Chiriqui lagoon proper is 32 miles long with a width varying from 5 to 12 miles. The entrance is over 3 miles wide with ten fathoms of water, which depth can be carried to all of the anchorages in this lagoon. The channel connecting it with Almirante Bay has a least depth of five and one-half fathoms but is narrow and crooked.

Almirante Bay, to which attention is principally called, is about thirteen miles in extent from east to west, but with its interior so filled with small islands that its shape and width is very irregular, the width varying from 2 to 13 miles. In consequence of its formation this bay has been said to possess harbors within harbors, in which vessels of the largest class may enter without

difficulty, and in many places lie alongside the shore in security. This bay has two entrances direct from the sea, known as Boca del Toro and Boca del Drago, both available, especially the latter, for large vessels.

The late Admiral Ammen in a memorandum to the Secretary of the Navy, stated that the Chiriqui lagoon was admirably situated for a coaling station, easily defended against naval attack and was conveniently situated for a naval force intending to control an isthmus canal by the way of Panama or Nicaragua. Captain (afterwards Admiral) Meade reported to the Department that its value to any power desirous of controlling the isthmus would be very great and undoubted. Most of its anchorages, he went on to say, could readily be prepared for defense in the event of war by the ordinary resources of a frigate's crew, and with a few cannon behind redoubts held against a fleet.

I will close this reference to Chiriqui by saying that, as a strategic harbor, in view of future possibilities in connection with the Canal, it has no equal on the coastline of the Caribbean or in the Central American portion of our continent. Of the other islands and ports bearing upon the Canal, it may be worth while to mention the Curaçao which is likely to be a port of coal and watering on the route to the canal and in a limited way the master of the Caribbean. If Germany, as some delight to prophesy, should ever absorb Holland, this island, as the coaling station of a strong military and ambitious naval power would become of greatly increased military importance.

Barbados, placed a little to the eastward of the regular chain of the Windward islands and opposite to a much used passage, would be greatly increased in commercial importance, but its inferior anchorages have caused the neighboring island of St. Lucia to be selected as the English naval coaling station and an establishment there of coaling facilities which will cause it also to be used as a general coaling port for the canal-bound vessels.

Martinique, of the same chain of islands, has been the naval station of the French in the West Indies and it has appliances, especially for docking and repair that excel anything private or governmental that exists in the West Indies, Spanish main or perhaps even our own gulf coast. Its further development by the French may be expected in the case of the opening of the Canal. Fort du France, the naval port of Martinique, was used

by the French as an advanced naval base in their operations against Mexico during the time of our civil war.

Jamaica, the largest of the English West Indies, holds a geographical position so important in a strategic sense that it has led to the establishment in Port Royal harbor of the principal English naval station in the West Indies. This station has a most important position with respect to the Windward Passage and to the routes from the northern ports of America to the Canal. It would be the natural base for operations against the Central American coast and was used during the war of 1812 as a base of operations against our Gulf coast and the city of New Orleans.

The island of Hayti, containing the two negro republics of Hayti and Santo Domingo, is interposed between Cuba and Puerto Rico. On account of the frequency of insurrections and the general instability of the government on this island, there is more reason to look for foreign interference than in any other country of the West Indies. In fact, the island with its two semi-civilized states forms the tinder-box, as it were, of the Caribbean. In possession of a foreign power, Samana Bay would leave open Puerto Rico and the Mona Passage and St. Nicholas Mole, and the bays and anchorages in southwestern Hayti could be used as a base of operations against Cuba and the Windward Passage. The Monroe doctrine, as understood at the present day, would not allow the occupation of any part of this island by any European power, except in connection with or anticipation of hostilities with the United States. As to other ports affording secure anchorages and in important geographical positions like St. Thomas and Carthagena, it may be said that so long as they remain under their present control they will have little effect upon the routes to and from the Canal. In the possession of a strong European maritime power, however, situated as they are upon the flank of trade-routes to and from Europe, they would become important factors in the Caribbean situation. It is not likely that our consent to such a transfer could be obtained. Without our consent it is doubtful whether such a transfer would be attempted.

In closing this examination of these waters it is well to emphasize the value of the command of the Caribbean upon the navigation of the Canal in war-time. A blockade upon the east

end stops the transit and use of the Canal. One cork is alone necessary for this bottle. With our great interests, our new acquisitions and our close proximity to these waters which would dominate our egress from our own Mississippi and Gulf ports as well as the Canal routes, it is imperative that no matter what demands may be made upon us from other parts of the world, that the naval force on the North Atlantic station should, active and latent, be sufficiently strong to have and retain the command of the sea in the Caribbean. This squadron or rather fleet does the duty that is covered by the English channel and the Mediterranean fleets combined. It should never be neglected, and always contain a sufficient number of the backbone of the fleet; that is, vessels competent to take the line of battle in time of war.

Proceeding to the Pacific Ocean we find that the trans-isthmian trade of the Pacific has for its focus at present the bay and port of Panama. Being one of the existing terminal points of the land-transit route across the isthmus of Panama, it has great value, which value will continue and be increased if the Panama Canal is constructed, but which will be diminished if the Nicaragua Canal is opened to the world. Even Panama would make a base of importance for naval operations to any country having the naval control of the Caribbean waters. From its almost insular conditions and isolation the transit land route would be most likely in the same hands and the necessary communication being maintained by that railway, Panama could be fed and supplied direct from the home country of the power dominating this sea in war-time.

The immediate port and anchorage of Panama is not capable of land defense but the little archipelago known as the Pearl Islands affords many facilities for operations as a base capable of being held by land and fixed defenses.

Along the coast of Central America, to the northward and westward of Panama, are the secure anchorages and natural harbors of Golfito, Port Culebra and Port Elena. They are of a depth sufficient for the largest vessels and with a capacity for defense but without any commercial importance or resources. Their proximity to the Pacific terminus of the Canal alone brings them within the limits of this discussion. In a naval way they would be superior to the little artificial basin proposed to be constructed as the terminal port upon the Pacific of the Nicar-

agua Canal as well as having a superiority, though in a less degree, to the neighboring and already established ports of Corinto, Amapala and La Union.

Acapulco, the best harbor in Mexico, is conveniently placed upon the west coast as a midway point of call and coaling between the Canal and San Francisco. As a naval factor in the Canal question, Mexico does not exist; it is off the route on the east coast, and but scantily developed upon the west coast. Its development and strength is as a military power, and its navy will be necessarily limited to purely coast-guard purposes. Hence, while Acapulco would figure as a port of much commercial convenience, it is hardly to be considered as having any naval weight in the matters under consideration. Even its limitations as a neutral port in time of war would serve as but a moderate restriction to the passage north and south of belligerent vessels. Magdalena bay, on the outer coast of the peninsula of Lower California, is also in Mexican territory, but is not a port of the convenience or resources of Acapulco. It would not figure in this problem unless an improbable alliance should be entered into by Mexico, or a belligerent, taking advantage of the naval weakness of the Mexicans, should disregard its neutrality and make it a rendezvous and base of operations. Even then it is not beyond the range of possible land operations from Southern California.

The geographical, topographical and climatic characteristics of southern California differ so much from those of northern and central California, from which it is separated by a transverse range of mountains whose lowest passes vary from 4000 to 6000 feet in elevation, that the subject of its naval and military situation should be considered to a great extent apart from that of the remaining portion of the State. The development of California has had several phases, each affecting the question of its resources for offense and defense by land and sea.

It seems hardly credible that shortly after its annexation by the United States announcement was made by one of the highest military authorities to the War Department at Washington that one great difficulty in defending California arose from the fact that breadstuffs would have to be sent from the Atlantic coast for the sustenance of the troops. The mineral, agricultural and horticultural eras of California have succeeded each other in

turn and yet this imperial State is but partially developed. It is not too much to expect that a commercial era will come to this coast and that the want of coal will be more than compensated by the improved use of petroleum which is found in such abundance in southern California. San Diego in the south, San Francisco in central California, the Columbia river in the north, and the bays and anchorages in Puget Sound and on the Strait of Fuca give commercial and, to an extent, naval ports whose future will be largely developed by the Canal.

The route approaching the great circle track to China and Japan from the Canal skirts the coast of California as far as San Francisco and the Aleutian Islands. This track may be readily followed by the tramp steamer seeking cargo and important ports of call, while the route via Honolulu with its better climatic conditions will be followed by the through cargo steamers and those carrying passengers for the Orient.

The break in our Pacific coast territory made by Vancouver Islands and British Columbia includes within its limits the naval harbor of Esquimalt with its strong fortifications in the course of erection. Beyond, on the same and adjacent islands, exists also one of the large sources of coal supply for the Northern Pacific. This island, with its naval harbor and dockyard, is now the only territory of a strong European power bordering upon the Pacific coast of America or to be found in the vicinity of our own Pacific coast-line.

The distance and isolation of this coast tends strongly to its naval defense from any power but Great Britain, which has behind its naval station the long line of the Canadian Pacific Railway with its steamer lines running south and west. This isolation from the great naval powers and their home ports will be ended if the Canal is considered in the light of a natural strait free to all navigators or masters.

Of all the countries on the Pacific Ocean, the United States is the only great power whose home territory borders upon this ocean. The development of the Pacific slope during the last half century has been phenomenal, and the naval resources of the coast have of late kept step with the development of the country. The services of the Oregon in the Atlantic campaign during the late Spanish-American war and of the Olympia and Monterey in the Philippines emphasize the fact that the products of the

workshops of this coast have become an important element in the naval force of the United States with an effect far beyond the limits of the territory in which they were created. To the possibilities for construction and repair appertaining to the dockyards at Mare Island and Port Orchard and the Union Iron Works at San Francisco have been added the private shops of Portland, Oregon, and Seattle as builders of torpedo-boats and torpedo-boat destroyers, and yet we are but in the early stages of naval development upon the Pacific coast. The Canal, with the facilities that it will afford for the transport of raw materials to the Pacific coast, will further develop the private and public shipbuilding plants of the coast.

With the great and growing population of the Pacific States, their excellent and increasing railway communications, and their comparative isolation from the great naval powers, hostile operations directed against the United States upon the Pacific slope will be almost exclusively confined to sea and coast operations by naval forces, aimed at our seaports for the control of our waters and the immediately adjacent territory and against our seaborne shipping both foreign and coastwise. The means of offense being almost exclusively naval, the means of defense must be the same, with fixed defenses for the coast ports of importance. The command of the sea on our north Pacific coast and the waters of the western basin of the north Pacific should be in our hands in peace and war-time. This can only be effected by readiness of a proper and sufficient naval force either on the spot or to be furnished from the Atlantic through an untrammeled Canal. In addition to this, and available for combination, should be the available forces normally attached to the Philippines and the waters about China, Japan and Korea. In other words, the Pacific Ocean from Samoa northward should be within our control.

To the vessels in commission should be added others in reserve at the two naval stations. An intelligent policy of combination and development should be followed as to these two stations, and the predominating natural advantages of each station should be utilized and no attempt be made at enormous expense to force conditions at one station which naturally exist and are presented at the other. Especially should it be remembered that the disadvantage of a diffusion of resources does not apply to drydocks,

for next to an actual want of docking appliances upon a sea coast is a want of proper and geographical distribution of these facilities. No naval stations of the United States should exceed in plant and supply of stores those upon our Pacific coast, for added to their importance are the disadvantages arising from their distance by land and water from the great manufacturing sources of purely naval material.

That the Aleutian Islands afford secure harbors for coaling stations, the Behring Sea trade and the greatly increased Yukon traffic have shown. These stations are also available as well for China and Japan by the northern routes.

Of the Hawaiian Islands but little more is needed to be said. Their value is evident as a stepping stone to Guam and the Philippines and by the southern route to China and Japan. They are the only group north of the equator with excellent harbors and with both natural and artificial resources, and capable of being self-supporting in case of blockade or isolation in time of war. They have some resources as a port of repair and coaling, and a cross-roads on the Pacific for steamer lines east and west and north and south.

In leaving the north Pacific Ocean to discuss the southern Pacific at the risk of repetition we will say that a predominance, both maritime and naval, in the north Pacific Ocean is an essential matter for the United States in regard to the interoceanic Canal. As the want of such naval predominance in the Caribbean would deny us access to the Canal on that side in wartime, so a similar want of naval predominance in the Pacific will prevent our ships gaining access to the Canal from those waters. The maritime preponderance in the north Pacific, though contested, is still ours, and to this should be added the naval predominance which, if it does not precede the maritime predominance, should at least accompany it. Such naval predominance and control would include—

1. A control over our own coast and especially over our northwestern water frontier.

2. A control of the waters about the Pacific terminus of the Canal.

3. A control of the Hawaiian group.

In the southeastern Pacific we have the Latin-American countries of Colombia, Ecuador, Peru and Chile; Chile alone

being of any naval strength, which is needed for her own and neighboring waters. It is not likely that these countries will enter into any entangling alliances with European powers and thus offer them the vantage ground of an American port for a base of naval operations. It is of course not improbable that unfrequented portions of the coast may be used for purposes of coaling notwithstanding the violation of neutrality involved; but this would only be temporary and to some degrees alone better than coaling at sea, for there are few places that are uninhabited and free from the Pacific swell. There is always danger, it is true, that a group of islands as well placed as Galapagos Island, acquiring new importance by the opening of the Canal, may be secured from Ecuador by some European power; but even if this were done, its rôle would be more of a port of coal or coaling than a port threatening the Canal. It would be on the flank of the south Pacific routes, but not in a vitally important position so far as we are involved in the matter. Whether the Monroe Doctrine would here be applicable would rest with our statesmen and with the light of our latter-day history upon the matter.

The islands and countries of the southwestern Pacific of any importance are in point of nationality, Samoa excepted, either French or English.

The French islands of the mid-south Pacific are centered about Tahiti and its principal port of Papeiti, which is both the political capital and the headquarters of the French naval division of the Pacific. In addition to the Society group, of which the island of Tahiti is the principal and most important, the French either control or definitely possess the Marquesas group, a rendezvous used by Commodore David Porter in the war of 1812, most of the islands of the Low Archipelago and of the Austral group, which latter includes the well placed and good harbor of the small island of Napa. In fact, Napa is all harbor, and as the island is midway upon the great circle route between Brito and Australia, it might well become of importance as a coaling port upon the opening of the Canal. Tahiti, however, has a certain amount of resources which Napa wants; and it has certainly a mid-ocean position, nearly equidistant from San Francisco, and Sydney in Australia, and about 2400 miles from Honolulu, Auckland and New Caledonia. It has, besides the port of

its capital Papeiti, an excellent natural harbor in Port Phaeton on its southern side, which may, if occasion requires, be further developed by the French for naval purposes.

The Samoan islands are nearly midway between the Hawaiian islands and Australia. The island of the group with which we as Americans are most concerned is that of Tutuila, in which is the harbor of Pango-pango. Of all the anchorages of the group this is the best, and it presents a very considerable anchorage area, so far sheltered as to be safe at all times, and presenting a depth of water sufficient to accommodate vessels of war of the largest class. It is on the flank of the trade-route to Australia and New Zealand, and is a valuable strategic point for the whole southwestern Pacific.

Commercially, this harbor or island is not likely to have great importance unless made a free port. Tutuila presents few resources, and the harbor, which is on the south side, extends inland to so great a distance as to almost cut the island into two parts. The harbor is so landlocked and protected as to have the quiet of a mountain lake, could be strongly defended, and is practically unobstructed.

With the wealth of the group upon the neighboring island of Upolu, with the best harbor on the almost unproductive island of Tutuila, and with three great naval and commercial powers striving for a predominant influence in the group, the Samoan question is a mixed one. To this complexity of the question is added the sentiment arising from the vessels and lives lost and the blood shed directly and indirectly by the present status of the question.

Certainly it would be the wisest policy to have the whole group under the protectorate of one power; if that cannot be realized and the United States desires to include the southern Pacific within its sphere of influence, then Pango-pango and its island should be fully acquired, developed and fortified. As a coaling station for peace time only, it is unnecessary and expensive. Without defenses, its rôle as a coaling station in a naval war seems absurd, as it would become either a burden to the fleet or an easy objective to any cruising vessel of the enemy.

The Fiji Islands and New Caledonia, though bearing certain relations towards each other and towards Australia and New Zealand, bear little in a naval sense towards the Canal. New

Caledonia, a French colony, is too far from Tahiti to permit any unity of action or mutual support between the two colonies.

The Fijis, offered more than once to the United States and Great Britain, were finally accepted by the latter country. There are some good harbors and the sugar product is considerable, but these islands are not likely to play any important part in a sea so thoroughly commanded by their rulers.

The study of Australia, with which for the moment I will include New Zealand and Tasmania, is interesting from a naval and commercial sense and as presenting a country newer than our own but developing under different conditions and upon different lines from the United States. The population of Australia is singularly homogeneous in its white men, being over 90 per cent. of British origin. Two peculiarities in the distribution of this population is of interest in connection with naval and military matters; the first is that all of the large cities of Australia are seaports, and the second is the very large proportion of the population residing in the cities. The agricultural population is sparse—the cities overcrowded. The two largest colonial cities of the British Empire are the Australian cities of Melbourne and Sydney, and these two with the city of Adelaide contain one-fourth of the entire population of the continent.

Australia may be considered as self-supporting so far as food supplies are concerned, but its purely military supplies come from Europe with the exception of some ammunition made at Melbourne. Both naval and military stores are, however, being accumulated in the principal ports, where excellent drydocks of large size now exist. Coal, that essential naval material, is found in New Zealand and New South Wales, abounding in the latter place, the New Castle mines near Sydney being the source perhaps of the greatest supply found upon the Pacific.

The high rates of wages cause much limitation in the way of manufacturing, and the comparative cheapness of sea transportation, carried on yet to an extent by sailing vessels, further retards development in that direction.

The local military force in the way of partly-paid and volunteer militia, in Australia alone, numbers about 50,000, and these can be readily concentrated at the large cities by rail or sea. To the regular Imperial British naval force on this station is added an Australian Squadron created by a mutual agreement and colonial

payments. In addition there is a naval militia in the state of formation.

The objects of the Australian Squadron were announced as—

1st. To provide a defense against attacks from armored vessels with ships of equal or greater power.

2d. To provide for the defense of commerce by cruisers of the latest type.

3d. To have in reserve in the colonies in the older corvettes, officers and crews to man the mercantile cruisers which would be employed in time of war.

4. To carry out the policy of the Pacific.

There are five places in and about the three Australian divisions that present themselves as important naval positions. They are Sydney, King George Sound, and Thursday Island in Australia proper, Auckland in New Zealand, and Hobart in Tasmania.

Before closing this brief study of the Australian Colonies, now partly federated, it would be well to call attention again in a military sense to their isolation and distance from European and Mediterranean waters. From Suez to Aden in the Red Sea the distance is 1310 miles, while from Aden to King George Sound in Southwestern Australia the distance is 4970 miles, while to Thursday Island off the north coast of Australia the distance is 5970 miles. From Sydney to San Francisco the distance is 6430 miles, while to Vancouver the distance is 6840 miles. In these days such distances are ignored on account of ready telegraphic communication, but fortunate it is, in a military sense, that so large a country, yet so greatly dependent upon the sea and sea communication, should have as a generous and indulgent mother country, one whose command of the sea is so universal and so undoubted.

The military and naval features of the Philippines is a subject of such every-day discussion that it hardly needs to be entered into. With the pacification of the country the present disproportionate attention to this group in a military and naval way will cease. With its retention under our government and flag will come of course a certain amount of naval importance and development. The station at Cavité will be retained undoubtedly until our naval rôle for the future is thrashed out, then if our requirements demand a station of security, defensibility and im-

portance independent of the resources of Manila, Subig bay seems to be the choice of those whose investigations and personal experience make them capable of judging.

The relative importance of the Philippines in the extreme East depends very much upon what rôle we are to assume or to be left to undertake in China. Whether we will advocate the open door in its full meaning or whether we will accept a territorial domain from China with its sphere of influence, is a matter concerning not only our trade relations but our naval position. If the latter policy be adopted then there will be a northern coaling and naval station to balance that of the Philippines and the value of the Philippines station will be decreased. If, however, we should seek for trade without using territory as a means we will center our naval resources in or about the island of Luzon and place there a coaling station, a repair station and a drydock of the largest size. We cannot depend upon the drydocks of Hong Kong in case of war.

There are, it is true, harbors either really or practically detached from the mainland along the coast of China and Korea that might be secured as coaling stations and made part of our territory for that purpose They might in time serve as trade centers, although primarily used for other purposes. These places would either require fortification or a probable command of the sea on our part in any war which we might be called upon to enter in these far-off waters. Hence, the acquisition of such territory should not be entered into lightly and all of the contingencies likely to follow should be carefully examined. Climatic, geographical, and trade reasons seem to favor a northern port, but if this acquisition should not be made, then the Philippines will serve our naval needs and a periodical change of climate should be made and followed rigorously as a routine necessary for the vessels of the United States in these waters in times of internal and external peace.

We will now consider the political conditions of the countries affected by the opening of the Canal and discuss their relations towards the United States.

Recommencing with the West Indies we find that the former Spanish Colonies of Cuba and Puerto Rico, now in our possession are, intrinsically and strategically, the greatest in value and importance of all the countries included within these regions.

Their population exceeds two millions; and the position of Cuba alone places these former dominions of Spain in a position of the highest importance towards the United States. Whatever may be the future political condition of Cuba, care should be taken that it should never be, by the possibility of an entangling alliance with a strong naval power, a menace or a source of danger to the United States. So conservative a statesman as John Quincy Adams is quoted as having often said—and we were a weak nation at that time—that we ought to make war upon the greatest naval power of the world rather than allow her to acquire Cuba.

Excluding the Bahamas, the British Colonies of the West Indies have a population of over a million, of which only about 3 per cent. or over 30,000 are whites, the remainder being either black or colored with mixed blood, and Chinese and Indian coolies. The decrease of white population is apparent from the fact that Jamaica two hundred years ago had 70,000 whites, while now it has about 15,000.

It may not be too discursive, in examining the British West Indian Colonies, to refer briefly to the forms and methods by which the Colonial Empire of Great Britain is administered.

The English Colonies, politically, can be divided broadly into three classes (India and the newer territories being excluded), as follows: 1st. The Crown Colonies; 2d. The Colonies where representative institutions exist in part or wholly, but where the executive and administrative power remains with the Crown; 3d. The Colonies possessing both responsible government and representative institutions.

1. The Crown Colonies, in general words, are those in which the Crown exercises a full control upon the legislation, and where the Colonial administration is carried on by officials appointed and controlled by the Home Government. Of the Colonies likely to be within the field of the Canal, Jamaica, Tobago, Trinidad and British Honduras or Belize and the Fijis are purely Crown Colonies. In Crown Colonies generally the white race is an insignificant factor of the population.

2. In the Colonies which possess representative institutions but no responsible government, the Crown cannot, as a general rule, legislate by order in council, the laws being made by one or both of the legislative houses with the concurrence of the

governor. At least one of these legislative houses is entirely, or in greater part, representative. Besides the veto power and the control of the executive, the Crown retains the power of appointment of the public officers.

There are several variations of this type of Colonial Government, such as that existing in the Bahamas, the Windward Islands and Barbados, where there is a council named by the Crown and an elective assembly in addition. In the confederation of the Leeward Islands there is one legislative house only, part elected by the people and part being named by the Crown. The whites are in a minority in the countries where this type of government prevails.

3. The Colonies possessing a responsible government and representative constitutions are not under the control of the Crown or Imperial Government beyond the appointment of a constitutional governor as representative of the Crown and a veto power upon legislation, which is rarely exercised. The Australasian Colonies (except Western Australia) and Canada, of which British Columbia is a part, are within the scope of this examination. It is hardly necessary to say that the population of these Colonies are almost wholly whites of European race and origin. A federated form of government is found in some of the Colonies of both the second and third classes.

The term of the Governor is at the pleasure of the Queen not to exceed six years. The Governor is not, unless especially invested, in direct command of the regular forces of the Colony. The Home Government for evident reasons takes exclusive charge of questions concerning the relations of the Colonies with other foreign powers, no matter how free the Colony may be. This includes the conclusion of treaties and conventions, naturalization, declaration of war and peace, and all military and maritime agreements. In noticing the complexity and variation of the English Colonies we must be led to realize its resulting flexibility, knowing as much as possible in essential matters the characteristics and customs of the various races with which it deals, and showing in part the reason which makes the English, par excellence, the most successful of all colonizers.

The French Colonies in the West Indies, termed by them—the French Antilles, consist of Guadeloupe, Martinique and the smaller islands pertaining to Guadeloupe. Martinique and

Guadeloupe form separate Colonies, each having its own government and, unlike the British Colonies, having representatives in the Senate and Chamber of Deputies at Paris.

The French Colonies have been classed in two groups—

1. Those which are endowed with representative institutions by which all local financial questions are decided; all organic laws or changes requiring the consent of the French Senate. The command of the forces and the internal administration is in the hands of the Governor appointed by the Home Government, who has under his orders all of the functionaries, including those of the army and navy. Martinique and Guadeloupe are of this group.

2. Those which have no general council or representative body, delegates from the municipal councils taking the place of this body by sharing in the discussions of the Privy Council. Tahiti and New Caledonia are of this group.

Of the other European Colonies existing in the West Indies which come within the direct scope of the Canal only St. Thomas and Curaçao can be considered important, and they are important only on account of their harbors and good geographical position.

The governments of Santo Domingo and Hayti, republics in name, are so unstable in their nature and so irregular and erratic in their administration of affairs that their nominal constitutions or political governments are not worthy of study. Of black and mixed race, their inhabitants range from an approach to civilization to but a few removes from barbarism.

The Central American countries, however, deserve a closer study on account of their close proximity to the interoceanic water-route. They are unfortunately of that type of Latin-American nationality with which we of the Navy are so familiar. On paper and theoretically they are republics and complete nationalities; as a matter of fact they lack the full powers and strength of stable sovereignty and it is a question if they really desire a full recognition of their rights as to national privileges and complete jurisdiction over their citizens in times of revolutions.

Geographically, Central America proper borders on the Pacific and the Caribbean and stretches from the State of Chiapas in Mexico on the north to the Department of Panama in Colombia

on the south, being in length about 900 miles, with a breadth varying from 30 to 300 miles and an area of 175,000 square miles. Both seacoasts are low, hot and comparatively unhealthy, the Pacific Coast being the better of the two and the more thickly populated. In the highlands of the interior the heat, however, is seldom oppressive, the climate varying with the elevation, which is so diversified as to give rise to the statement that no country in the world presents a greater variety of climate upon an equal extent of surface.

The political history of the Central American republics since the viceroyalty of Guatemala was terminated by the overthrow of the Spanish rule, has been one of attempted union, first with Mexico and then with each other, varied by internal revolutions and external wars between the several states. All attempts of permanent federal union have been unsuccessful and it is the opinion of the most enlightened public men of Central America that any union will be possible only when personal and revolutionary governments shall have ceased to exist in these separate countries, and when alternation in power, under constitutional law, shall have been established for several successive periods in all of the Central American States. With this deliberate and well digested opinion added to the historical experience of the past, we can only add the opinion, founded upon personal observation, that Central American union from internal action is neither possible for the present nor probable for the future. As a result of the present political state in Central America, with small, weak and unstable States, jealous and warring against each other, there exists a great want of development in their valuable agricultural, mineral and commercial wealth.

Practically, there are no manufactories, while the absence of roads and the difficulty of communication make mining unprofitable and commercial interchange difficult. This want of facilities for intercommunication militates against any extensive intermingling of the people and consequent political union.

Although the Central American States have written constitutions, in the main copied from our own, providing for popular representative institutions and peaceable changes of government, their internal history is one of constant strife towards their neighbors, and revolutions and dictatorships at home.

Various attempts have been made at white colonization along

these coasts under the official cognizance of the various Central American republics by European companies without any permanent results, notwithstanding the desirability of the high lands in the interior for residence by the white race.

The international questions between the United States and the various Central American republics have been various and many, the most important ones being due to the question of transit and the construction of an interoceanic Canal through Nicaragua, and the proposed or threatened acquisition of various portions of Central American territory at Belize, the Bay Islands, and in regard to the protectorate existing over the Mosquito Reservation. In addition to these questions, there has been the attitude of the United States, as a friendly and neighboring nation, as mediator between Mexico and Guatemala, and with the Central American republics individually and collectively in regard to their union as one nation.

The water-route afforded by the San Juan river to the lakes of Nicaragua early attracted the attention of some of our countrymen, and the Atlantic and Pacific Ship Canal Company was formed and secured a charter from Nicaragua August 27th, 1849, over fifty years ago. This charter for a ship-canal met with a serious obstacle at once on account of the claim to the whole eastern coast of Nicaragua by the Mosquito Indians, over whom Great Britain then exercised a protectorate. Although this claim was not recognized by us, still any attempt to force a canal through this territory would have caused difficulties two serious to allow of the commencement of such an enterprise. Hence, Secretary Clayton, of our State Department, requested the British Government to withdraw all claim to this coast so as to permit the construction of a canal under the joint auspices of the United States and Nicaragua. This was declined, but the British Government agreed to enter into a treaty for a joint protectorate over the proposed canal and water-route. From the negotiations and correspondence which followed upon this subject arose the Clayton-Bulwer treaty, which was made in Washington, April 19th, 1850. This treaty is remarkable as being the only case in which the United States ever allowed itself, so far as I know, to join with any European power in the arrangement of political matters upon the American continent, and it is especially singular that it undertakes to settle a question

more important to the United States than any other likely to ever arise outside of its own territory.

The most important article in this treaty is the first which reads as follows:

"The Governments of the United States and of Great Britain hereby declare that neither the one nor the other will ever obtain or maintain for itself any exclusive control over the said ship-canal; agreeing that neither will ever erect or maintain any fortifications commanding the same, or in the vicinity thereof, or occupy, or fortify, or colonize, or assume or exercise any dominion over Nicaragua, Costa Rica, the Mosquito Coast or any part of Central America; nor will either make use of any protection which either affords, or may afford, or any alliance which either has, or may have, to or with, any State or people, for the purpose of erecting or maintaining any such fortifications, or of occupying, fortifying, or colonizing Nicaragua, Costa Rica, the Mosquito Coast or any part of Central America, or of assuming or exercising dominion over the same; nor will the United States or Great Britain take advantage of any intimacy or use any alliance, connection, or influence that either may possess, with any State or Government through whose territory the said Canal may pass, for the purpose of acquiring or holding, directly or indirectly, for the citizens or subjects of the one, any rights or advantages in regard to commerce or navigation through the said Canal which shall not be offered on the same terms to the citizens or subjects of the other."

The other articles provide for the common use in war-time of the Canal, its neutrality, the protection of the parties and properties engaged in the construction of the Canal; the use of influence with other States to facilitate the construction of the Canal, and for the invitation to other States to join in the participation of the rights and guarantees.

In the second article, which provides for the neutralization, or rather freedom, of the Canal, the reading is as follows: "Vessels of the United States or Great Britain traversing the said Canal shall, in case of war between the contracting parties, be exempted from blockade, detention or capture by either of the belligerents, and this provision shall extend to such a distance from the two ends of the said Canal as may hereafter be found expedient to establish."

In the eighth article is found the singular provision which extends this treaty over any other interoceanic canal or railway at Tehuantepec, Panama, or any other part of the isthmus connecting North and South America. This provision was made notwithstanding the existence of a special treaty in full force with New Granada (now Colombia) and the United States which had been made in 1846, and which will be discussed later. Notwithstanding the Clayton-Bulwer treaty and its requirements, Great Britain did not formally relinquish her dominion over the Bay Islands until 1859, and her protectorate over the Mosquito Indians until 1860, and Belize is still a British Colony. It is, however, fair to say that when the ratifications were exchanged both Mr. Clayton and Sir Henry Lytton Bulwer declared that the question of Belize was not included in this treaty; but this is not shown in the body of the treaty as duly confirmed by the Senate of the United States.

In 1867 a treaty was concluded between the United States and Nicaragua which guaranteed on the part of the United States the neutrality and innocent use of any transit route through Nicaragua, and extended the protection of the United States over the same. This treaty gives to the United States and to their citizens and property, the rights of interoceanic transit over any route now existing or to be hereafter constructed, Nicaragua reserving the rights of sovereignty over the same. The United States in their turn agree also "to employ their influence with other nations to induce them to guarantee such neutrality and protection." Nicaragua further undertakes to establish a free port at each terminus of the transit route; gives the United States liberty to carry troops and munitions of war in their own vessels, unless these are intended to be employed against Central American States friendly to Nicaragua, and gives in the sixteenth article additional powers in the following terms:

"The Republic of Nicaragua agrees that, should it become necessary at any time to employ military forces for the security and protection of persons and property passing over any of the routes aforesaid, it will employ the requisite force for that purpose; but upon failure to do this from any cause whatever the Government of the United States may with the consent or at the request of the Government of Nicaragua, or of the minister thereof at Washington, or of the competent legally appointed

local authorities, civil or military, employ such force for this and no other purpose; and when, in the opinion of the Government of Nicaragua, the necessity ceases, such force shall be immediately withdrawn."

"In the exceptional case, however, of unforeseen or imminent danger to the lives and property of citizens of the United States, the forces of said Republic are authorized to act for their protection without such consent having been previously obtained."

This treaty was to remain in force for fifteen years and can be abrogated on one year's notice from either contracting party.

The Republic of Colombia, which has a coast line both on the Caribbean and the Pacific, and is an important factor in the Canal question from the fact that the Department, formerly State, of Panama, which includes the isthmus, is within its territory.

On the 5th of August, 1886, a new constitution was adopted and put in effect in Colombia which changed this nationality from a loose confederation of sovereign States to a strong centralized and almost autocratic republic.

The most important of the nine departments of Colombia is Panama, within whose limits is the Panama railway and canal route; the whole length (from east to west) of that department is 360 miles, but the irregularity of its coasts gives 400 miles coast line in the Caribbean and 600 miles on the Pacific. Of the importance of this department and isthmus it is hardly necessary to speak; nor will I recount its past history except to refer to one or two of the most important political incidents, the first one worthy of mention being the Panama Congress. This Congress was called at the suggestion of Simon Bolivar and was to be composed of representatives of all the American republics, for the purpose of counteracting the aggressive movements that were feared from the "Holy Alliance" of several European countries. Much was expected from this Congress, and a resistance was intended to be made to possible movements on the part of this holy alliance to conquer the Spanish Colonies. Deputies were appointed from Colombia, Central America, Peru and Mexico only—with passive delegates from the United States and Holland.

As planned by Bolivar this Congress had originally military as well as political purposes; the military objects were to be the adoption of certain measures to resist any new attack by Spain

and France against the Spanish-American republics; the other object being a closer and more cordial commercial and political understanding between the new republics and the United States. The military objects of the Panama Congress were furthered most effectively by an announcement made by President Monroe at this time with the cordial support then of Great Britain. This declaration has since become famous as the "Monroe Doctrine," and was made by President Monroe in his message to Congress in 1823. It reads as follows: "With the existing colonies or dependencies of any European power, we have not interfered and shall not interfere. But with the governments who have declared their independence and maintained it, and whose independence we have on great consideration, and on just principles acknowledged, we could not view any interposition for the purpose of oppressing them, or controlling in any other manner their destiny, by any European power, in any other light than as the manifestation of an unfriendly disposition towards the United States."

The general treaty of Amity, Peace and Commerce, concluded in 1824 between the United States and the republic of Colombia (then composed of New Granada, Venezuela and Ecuador), was the first treaty with the new Spanish-American republics. In 1831, the three countries referred to above became separate, independent republics. During the administration of President Polk, in 1846, a treaty was made with New Grenada which in article 35 includes two guarantees which are most important. The first says that:

"The Government of New Grenada guarantees to the Government of the United States that the right of way or transit across the isthmus of Panama upon any modes of communication that now exist, or that may be hereafter constructed, shall be open and free to the Government and citizens of the United States and for the transportation of any articles of produce, etc., belonging to the citizens of the United States, etc," and, in turn, the "United States guarantee positively and efficaciously to New Grenada by the present stipulation, the perfect neutrality of the before-mentioned isthmus, with the view that the free transit from the one to the other sea may not be interrupted or embarrassed in any future time while this treaty exists; and in consequence the United States also guarantee, in the same manner, the

rights of sovereignty and property which New Granada has and possesses over said territory."

This treaty was for a term of twenty years, and to continue in force until twelve months from the time that one of the parties "notifies the intention of proceeding to a reform." This treaty is still considered in force by both nations, though the term of its duration, as named in the body of the instrument, has expired, and it is continued upon the limited basis fixed for its extension, that is from year to year. It has been ruled by our government that though this treaty binds the United States absolutely to guarantee the neutrality of the isthmus upon the demand of the proper party, it does not oblige the United States to defend the isthmus from a body of insurgents against Colombia except so far as to preserve the free transit across the isthmus.

Under the treaty the United States is authorized and required to protect the transit of the isthmus from foreign invasion and authorized to require Colombia to keep the transit free from domestic disturbance. For this purpose the United States can use such military and naval forces as may enable them to assist Colombia to keep open the transit.

It is not necessary to recount the times that the armed forces of the United States have been called upon to interfere to protect the transit across the isthmus. It is sufficient to say that the rights and guarantees given by this treaty have been duly assumed by us, and tacitly acknowledged by the rest of the world.

In 1864 it was feared that Spain would attempt to send troops and munitions of war across the isthmus of Panama to be used against Peru. Although the obligation did not actually arise in this case, the Attorney-General of the United States, to whom the case was referred, decided that under this treaty it was obligatory on the part of the United States to prevent such warlike measures. In 1856, 1868 and 1870 endeavors were made by the United States to make new and additional treaties upon this subject but without final success.

On March 25th, 1878, a canal concession was made by the Colombian Government to Lieut. Wyse of the French Navy, which he in turn, with the consent of the Colombian Government, transferred to M. de Lesseps. Under this concession the Panama Canal was commenced and partly constructed.

Notwithstanding this concession to a corporation mainly composed of foreigners, and their subsequent acquisition of the Panama Railroad (which still remains, however, nominally an American corporation), the Government of the United States considers that its treaty obligations remain the same. President Hayes said in 1880: "Without urging further the grounds of my opinion, I repeat in conclusion, that it is the right and duty of the United States to assert and maintain such supervision and authority over any interoceanic canal across this isthmus that connects North and South America as well as protect our national interests." Secretary Evarts further announced to our minister to Colombia in 1880 that: "It is, however, deemed prudent to instruct you with all needful reserve and discretion, to intimate to the Colombian Government, that any concession to Great Britain or any other foreign power, looking to the surveillance and possible strategic control of a highway of whose neutrality we are the guarantors, would be looked upon by the government of the United States as introducing interests not compatible with the treaty relations which we maintain with Colombia."

President Cleveland said, in referring to our action in 1885 in sending a force to open and guard the transit after the burning of Colon: "The prompt and successful fulfillment of its duty by this Government was highly appreciated by the Government of Colombia, and has been followed by expressions of its satisfaction." The performance of this duty by the naval forces of the United States in 1885, while the canal was in process of construction by a French Company, was in the presence of English, French and Chilean naval forces, who were silent witnesses of this action of the United States, tacitly acknowledging the primary responsibility of the United States in the matter.

The dispatch by the Navy Department in 1880 of the Kearsarge to Chiriqui lagoon and of the Adams to Golfito in the Gulf of Dulce, for the purpose of establishing coaling stations or of investigating the advisability of so doing, led to considerable excitement in the State of Panama and in Colombia generally. The Colombian Government disclaimed any unfriendly intention and our Government withdrew the ships from these places, or at least was enabled to announce the fact of their withdrawal, at the same time stating that, "this Government was

aware that the acquisition of such places, whether by purchase of private property, or by public grant, would need be brought to the notice of the Colombian Government, and it has never entertained a doubt that its assent would be cheerfully given."

In answer to a proposition from Lord Granville, then English Minister of Foreign Affairs, that the American Government should invite other powers to participate in an agreement based upon the Clayton-Bulwer treaty to protect or guarantee the neutrality of the Panama Canal route, Secretary Frelinghuysen, in declining, stated that the President of the United States believed that the formation of such a protectorate over the isthmus transit would be in conflict with a doctrine which had been asserted by the United States for many years.

The countries of South America, both on the Caribbean and the Pacific Ocean, not already mentioned, have but a remote political relationship with the questions clustering about the Canal. The closeness of the commercial relations existing between these countries and England and Germany give rise to more intimate politico-commercial interests between these countries than exists generally with the United States. The Pan-American conferences and the recent undertakings in the way of an expansion of trade to the Latin-American countries give evidence of closer relations yet to come in the way of trade and, so far as trade and mutual dependence is concerned, in the way of a common and harmonious policy. Certainly, the more intimate communication resulting from the opening of the interoceanic Canal will lead to closer political relations without affecting in any way the independence of action and policy of these countries.

The countries in the western Pacific, like Australia and New Zealand, are English Colonies with the freedom of trade and regulation of trade that pertains to all of England's possessions. The other countries to be considered are China, Japan, Korea and Siberia. The manifest interests of this country lie with the policy of an open door, and already large shipments from the United States are made to all ports, directly or indirectly, extending from Vladivostok in the north to Singapore in the south. It is hardly probable that the trade of Russian China and Korea will be fettered beyond that of the home country of Russia; and for China itself our trade interests, so steadily growing of late,

will compel a political policy on the part of our Government for as much freedom of trade at least as we give to the European world. An entanglement in the struggle for supremacy in China and Korea will probably be avoided by our country except to establish the proper amount of freedom in trade. With the islands of the Pacific our policy should be the same. It is our duty to prevent the Pacific Ocean from becoming a sea in which American commerce is restricted or made in any way hostile to American trade.

In reviewing, finally, the existing and probable conditions surrounding the Canal question, let me recall to your attention again the military and strategical importance of the waters and islands of the Gulf of Mexico and the Caribbean Sea. The islands which border the various routes to the Canal through these waters are held, with the exception of Cuba, Hayti and Puerto Rico, by European powers, and their political affiliations are foreign to us. The fact that the use of the Canal can be prevented by a naval predominance in the Caribbean has been called to your attention repeatedly. It is not necessary to go to the Pacific when the control of the Caribbean, so readily accessible to Europe and the United States, will close the Canal to the world. As an accessory to this control the islands in the possession of France and England would serve as natural bases and coaling stations. An element to be considered, however, is the one that these insular countries, though now foreign to us, are being drawn daily by their commercial interests to a closer relationship to the United States. This fact will not fail in time to affect their political relations with us, as political interests, in this material age, are gravely affected by commercial interest, and in this case by the fact that the United States, from their wealth, great population and proximity, furnish to the countries of the West Indies the great market for their products, especially sugar, tropical fruits and tobacco.

As to the Central American States, so near to the future ship-canal, we find here such evidences of political weakness externally and internally, with so little prospect of change for the better in the future, that the consideration of other and stronger nations upon them cannot be avoided. As an evidence of their weakness let me refer to the fact that the conquering race in America—the European whites—number now in their pure de-

scendants less than one-third of the population, and that the remaining two-thirds consist of unwarlike Indians or degenerate mixed races. And even Costa Rica, with its larger population of whites, is no exception to the rule of weakness and instability.

I have said that in my opinion no security, stability or strength will ever come to these Central American countries collectively or individually without either external assistance or a general colonization. It is more than likely that the Nicaragua Canal, when built, will bring either one or the other of these to the States immediately about it. To emphasize the necessity, let me recall the fact that Walker, in his filibustering expedition, with but 1200 white adventurers of all nationalities, actuated by no lofty or national sentiment, made himself master of Nicaragua and continued so, even after he had cut off his supplies of men and material by his blundering quarrel with the Transit Company; and another striking instance in Costa Rica, when a squabble between two mercantile houses about legislation for a railway, led to an overturning of the government by a revolution caused by a force of sixteen men concealed in an ox-cart. These instances may lead us to appreciate more tangibly the internal weakness of the two States the territories of which will touch and include the interoceanic waterway known as the Nicaragua Canal.

The United States and Great Britain are the two great powers that have by various means exerted the most influence upon the Central American States. This has been more particularly brought to bear upon Nicaragua, Honduras and, to a less degree, Costa Rica, and mostly from matters arising directly or indirectly from the questions of interoceanic transit.

The relations on the part of the United States to these countries have been generally that of a friend and protector. Salvador at one time wished to join our federation; we have been appealed to frequently as a mediator; and more than one treaty has been formulated giving us the right and duty of protecting the sovereignty of Nicaragua and other States. Of all our treaties concerning these countries the most prominent and important one is that with Great Britain, known commonly as the Clayton-Bulwer treaty.

The first great and serious disadvantage which is found in connection with this treaty is the unlimited and perpetual nature

of the obligations, the treaty having no limit or time of expiration. The defects of perpetual treaties are obvious; these treaties are now generally condemned and will probably be seldom negotiated in the future. John Stuart Mill, in discussing the subject of such treaties, said that—"Nations should abstain from imposing conditions which on any just and reasonable view of human affairs cannot be expected to be kept. And they should conclude their treaties as commercial treaties are usually concluded, only for a term of years."

The first article of this treaty is open to objection on account of the prohibitions and limitations it places upon the United States—the leading and predominating power upon the North American Continent—and it is especially objectionable because we cannot, by its terms, aid or protect our commerce, and indirectly our Pacific territory, by establishing the necessary coaling stations within the limits of the Central American States or by landing a sufficient force to protect our transit, our citizens, or our trade.

The second article is objectionable because it allows the use and traverse of the Canal by the fleets and vessels of war of Great Britain, on their way, it may be in war-time, to attack our Pacific home coast or insular territory. We are denied by the terms of the treaty the right to detain, blockade or capture such a force no matter how inimical.

The eighth article states, in violation of the Monroe Doctrine as now interpreted, that the two countries, one European, "not only want to accomplish a particular object but also to establish a general principle," which is no less than a protectorate over the other transit routes proposed at Panama and Tehuantepec.

It is safe to say that it is practically the opinion of all Americans that this treaty should either be abrogated or very materially modified. The change of conditions since the signing of this treaty, due to our new West Indian acquisitions and more especially to the great development of our Pacific coast and territory, should cause Great Britain also to see the desirability if not the necessity of this action. The preservation of the treaty and its consequent limitations is not a vital matter to her and her commercial interests and future policy will probably not suffer by the disappearance of the Clayton-Bulwer treaty as a bone of contention between the two countries.

To understand more clearly the present unsatisfactory condition of affairs existing under the three treaties now in force with the United States bearing upon the subject of the Canal, a brief summary will be given of the method proposed in each for dealing with the international relations of the Ship Canal.

In the treaty of 1846 with New Grenada (now Colombia) the United States guarantee positively and efficaciously the perfect neutrality of the whole isthmus of Panama and also the rights of sovereignty and property which New Grenada has over the isthmus. As a single nation can hardly guarantee neutrality this really means protection. At the same time, it is true, Colombia can obtain the same guarantee of protection from other nations, there being nothing but the moral influence of the United States to prevent this or even to prevent after due notice an abrogation of this treaty of 1846.

In the Clayton-Bulwer treaty of 1850, the United States jointly guarantee the neutrality of the Canal, so that it shall be forever open and free, and they further agree to protect it from interruption, seizure or unjust confiscation. In case of war between Great Britain and the United States all vessels of either power traversing the Canal are to be exempt from blockade and detention. The two powers further agree to ask every other country to join them in the above stipulations and announce the desire to establish these stipulations as a general principle.

In the treaty of 1867 with Nicaragua—the Dickinson-Ayon treaty—the United States extend protection to all proposed canal and transit routes in Nicaragua, and guarantee the neutrality and innocent use of the same. The United States also agree to employ their influence with other nations to induce them to guarantee such neutrality and protection. In this treaty provision is made for landing forces of the United States to protect the transit or the lives and property of Americans. This treaty denies the use of the Canal to hostile cruisers by the words, "guarantee the neutrality and innocent use of the same."

The various propositions concerning the use of the Canal in time of war can be placed broadly under three heads, as follows:

1. A neutralization of the Canal in part; but with free access to and through it and its terminals in time of war, to troops, munitions of war, and to vessels of the naval and mercantile marine of the belligerent powers. This neutralization to be

effected by a joint guarantee from all of the great powers, the sovereignty of the country through whose territory the Canal passes being also guaranteed in the same manner.

2. A complete neutralization of the Canal in war and peace. This to include, in time of war, the denial of access to and through the Canal by the troops, munitions of war and vessels of war of the belligerent powers. The guarantee of neutrality to be made by all of the powers, and the country or countries through which the Canal passes to enforce its neutrality with the assistance of the United States as the power most concerned.

3. The absolute control and supervision of the Canal in peace and war-time by one nation—the United States.

The *first* proposition for *partial* neutralization, but allowing the Canal to be used as a free highway in time of war for armed forces is virtually the one agreed upon in the Clayton-Bulwer treaty. As the great naval power of the world, Great Britain does not fear the free use of the Canal by other naval powers, if she has the same right. So far as the Suez Canal is concerned, Great Britain deems it necessary to keep it open for her war-vessels and troop-ships as the shortest route to India, a route which if denied to her in certain contingencies, might endanger her hold upon the Indian Empire. This rule applied to the American Canal would be to our great disadvantage and also to the disadvantage of the comparatively weak nationalities upon the west coast of America.

These latter nationalities, like our own west coast and Pacific islands, would lose the military advantages they possess from their comparative isolation, and distance from the home country and naval stations of the European powers. With the free use of the Canal in time of war and with the naval bases for offensive operations now existing in the West Indies under the control of France and England, these countries could be made to feel to a greater extent the pressure and influence of the European powers. Furthermore, no matter what paper declarations might exist, a canal made a free strait as it were, in time of war would become from the force of circumstances part of a water area whose command was to be secured, and hence become a battle-ground or scene of blockade, useless for commercial or naval purposes in war-time.

The second proposition, providing for a complete neutralization, is practically the same as the conditions prescribed by the

treaty of 1867 with Nicaragua. It would deny the use of the Canal to cruisers hostile to the United States, but in time it would prevent the use of the Canal by our own vessels of war, and the transfer in time of war of naval force from the Atlantic to the Pacific and *vice versa*, no matter how vital such a movement may be. It would continue thus all of the military disadvantages that exist, and would be in opposition to one of the great reasons that is urged for the construction of the Canal as a matter of large national policy and self-protection. The possibility of what might occur can be forshadowed in studying the varying programmes of Great Britain towards the Suez Canal, as in 1877, when she virtually threatened Russia with war if she blockaded the Suez Canal; while in 1882 Great Britain herself seized the Canal, held it from end to end and made it a base of supplies and hostile operations.

The third proposition for a canal exclusively owned or controlled by the United States in war and peace means the direct or indirect purchase or construction of the Canal by the Government of the United States. In time of war it would mean a navy of sufficient size and strength to maintain the Canal open against an exterior attack from any power or alliance of powers with the force they can spare from European waters. Local fixed defenses might prevent the occupation of the Canal or its terminal ports, but a blockade at either end will suspend the free use of the Canal upon an occasion when its use might be of the greatest military necessity, and nullify one of the great purposes for which it would be constructed as a national undertaking. It would force the passage of an Oregon or a fleet to be as now through the Strait of Magellan. It has been stated that the Suez Canal has been neutralized in time of war, but this statement is made without a full knowledge of the present status of the matter and certainly in face of the actual passage through the Canal of a belligerent force in the late war with Spain under Camara aimed at our fleet in the Philippines.

The status of the Suez Canal is as follows: On the 29th of October, 1888, a convention was drawn up and signed at Constantinople by nine of the European powers to make free the Suez Canal in war and peace to all vessels, public and private, belligerent or neutral, without distinction of flag. The free use of the Canal was not to be interfered with by the parties to the convention even by the exercise of the right of blockade. No

act of hostility was to be committed within the limits of the Canal nor its terminal ports nor within a radius of three marine miles from these ports, even if the Ottoman Empire or Egypt should be one of the belligerent powers. The Canal was to be under the same general conditions as a neutral port with respect to the stay or sailing of opposing belligerent vessels. The Sultan of Turkey or Khedive of Egypt, however, were to be free to use the Canal for military purposes when the defense of Egypt or the maintenance of public order required it.

Great Britain, as a party to this convention, only agreed to it subject to a very important reservation, which was that the application of the rules of the convention was not to embarrass or fetter the liberty of action of the British Government during the period of the occupation of Egypt by the forces of the Queen of England, which period was referred to as a "transitory and exceptional" state of affairs. As this state of affairs is indefinite in its limitations, so the reservation is indefinite, and owing to this fact the terms of the convention have not been brought into practical operation, and the status of the Suez Canal in war or peace is practically what the British Government chooses to make of it.

Let me call attention to a few of the naval aspects of this question. The first thing that presents itself in connection with the canal and our profession is the necessity for a strong naval force for the United States. Separated as the Canal and its immediately adjacent territory is from the territory of the United States by Mexico, the approaches to the Canal require naval protection in order to give us the status here that Great Britain enjoys at Suez. Nothing would conduce more to the safety and protection of these Canals and the beneficent flow of the commerce therein than the control of the Suez Canal by Great Britain and the control of the American Canal by the United States.

It has been said that the changes forced upon us by the Canal will be so great that it would be better for us if no canal were to be built. I do not believe it to be so, but it does not matter; the Canal is inevitable and its eventual opening is but a question of time. We have contributed towards the solution of the question by our official surveys, and have allowed the Panama Canal to be begun and partially constructed. The completion of a great Ship Canal, aided to a greater or less degree by us, will cause a still greater remove from our former policy of isolation from

the affairs of the other great powers of the world. The great commerce coming from European maritime countries, passing on its way to and from the Canal near our Gulf territory and West Indian possessions, will revive to European countries the importance of their West Indian Colonies. It will bring these Colonies in even closer relations to us than they have been drawn of late years, creating and reviving through them many questions in which we will have either joint or antagonistic interests with their home governments.

It will be neither reasonable nor possible to debar or restrict certain European interests and rights upon and along these waters in connection with their trade through this water highway of the world.

The questions that will arise about the Canal will be almost exclusively maritime and with the great naval powers. To meet these powers with any tone of strength or pretence of equality in these matters we must have a competent naval marine; or otherwise we will experience those interpretations of international law that are reserved for the less vigorous nationalities and the weaker naval powers.

To perform the duty of protecting and keeping the Canal open to the commerce of the world, as well as the imperative duty of protecting our own trade, a competent naval force is essential. In other words, a naval predominance in these waters is essential; for after all no matter what treaties exist or are made, the control of the Canal will rest with the nation having control of the Caribbean Sea.

For this naval force there must be naval stations in the Gulf of Mexico and the Caribbean Sea to furnish facilities for coaling, docking and extensive repairs to ships and machinery, and also to serve as depots for military and naval supplies of all kinds. To accomplish the naval duty which has been thus foreshadowed, in addition to the increased demands made upon us by our distant acquisitions in the Pacific, means more rapid progress and more actual work in the increase of the Navy. There is no royal road to the construction of a modern and efficient Navy, and Acts of Congress with limitations that make them a nullity keep us behind while others are stirring and progressing. With our great wealth, ample resources and prosperity, this naval increase can be made without strain, and thus possible humiliation and disaster averted in the future.

164° 163° 162° 161° 160° 159°

DE LONG MOUN

Mt. Kelly

66°

Kuveleak R.

Wōleek R.

INLAND RIVER

NOTOARK OR

Shu-puck

Village

BAIRD MOUNTAI

Loaf

Lump

Bald

Squirrel or Shungnak to arik R.

Kat-ga-ruk R.

Kobuk R.

Hunt R.

67°

She-sur-ark-lik-a
(Trading Station)

Gill

Alp

Spoon

COAL VEIN

KOTZEBUE SOUND

Hotham Inlet

dries in patches

Kiv-a-tar-g-ga-roak
(Trading Sation)

KUBUCK OR PUTNAM RIVE

Wink

Duer

Leader

Hotham

Hunt

WARING M

Ik-ku-go-ak R.

Nu-le-ar-go-rik R.

Ka-o-

C. Blossom

Pt. Nimrod

C. Espenberg

SELAWIK L.

SELAWIK

Kanug-ga-row-che-uk

Shupwik

RIVER

Inland L.

Nah-park-la-lik

Kig-ga-ik-o

Mar-go-ak R.

Eschscholtz B

Chariss Pen

Chamisso I.

Good Hope Bay

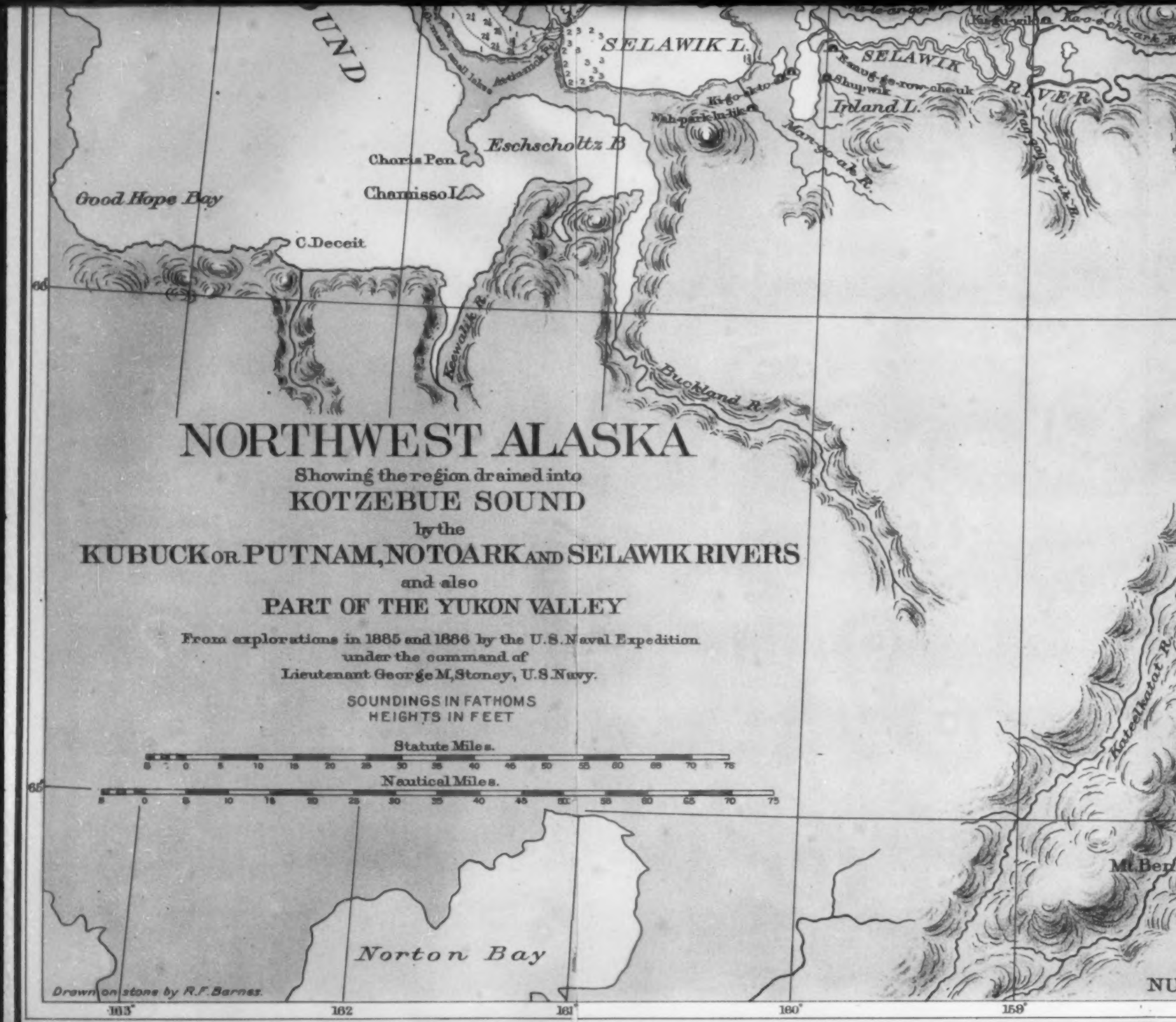
C. Deceit

66°

158°
157°
156°
155°
154°
153°
NTAINS
Too-loo-uk
Colville or Kun-yo-nook R.
Nu-dru-yuk-puk
Chandler L.
MELVILLE
Blair-luk R.
RILEY PASS
NAVY PASS
Ar-e-yuk
Shot-kol-uk
Ish-she-yuk
O-em-o-ne-look
Nim-yuk
My-o-ga-a-gal-uk
NOTOARK RIVER
Caribou R.
Nim-yuk
(Cottonwood)
SCHWATKA MTS
Nuck-ruk-to-ark R.
Koo-too-ark R.
Singing-a-look R.
Red Stone R.
E-vel-she-ark
Tuk-a-hee-la L.
Nuh-tuk R.
(Owl R.)
Ambler or
Hot Springs
Ah-lus-ga-wik
Kah-lu-look-to-ark
(Big Fish)
Walker L.
Spoon
Greenstone
Kateel
Jade
Bearbone
Bald
L.P.
A-koo-look R.
Portage
Howard
Whale
Fort Cosmos
WINTER QUARTERS 1885-6
Kah-lo-mute
L. Selby
Now-low-vuk-to-ark L.
Now-get-to-ark
Gull L.
Selawik
Nub
PUTNAM RIVER
Par R.
Ko-ka-chat-na R.
ZANE PASS
Mt. Purcell
LOCKWOOD MTS
Al-lash-look R.

164°
163°
162°
161°
160°
159°
DE LONG MOUNT
Mt. Kelly
66°
Kuvelook R.
Wolcek R.
INLAND RIVER
NOTOARK OR
Shu-quck
Village
BAIRD MOUNTAIN
Loaf
Lump
Bald
Squirrel or Shaneshaw Creek
Kateg-ro-ok Creek
Kaka-ruk R.
Kate
C. Krusenstern
She-sur-axe-lake
(Trading Station)
67°
Gill
Alp
Spoon
COAL VEIN
KOTZEBUE SOUND
Hotham
Inlet
dries in
hatches
Ri-ta-rg-ga-roak
(Trading Station)
KUBUCK OR PUTNAM RIVER
Wink
Duer
C. Blossom
Leader
Hunt
Lake
Hotham
WARING MO
Ik-ku-go-ak R.
C. Espenberg
Nu-le-ar-go-wik R.
Kue-ga-ruk R.
Ku-gu-wik
Kao-e-he-ark
SELAWIK L.
SELAWIK
RIVER
Shupwik
Inland L.
Ki-go-ik-to-rok
Nah-park-lu-ik
Mar-go-ak R.
Eschscholtz B
Chorris Pen.
Good Hope Bay
Chamisso I.
C. Deceit

158°
157°
156°
155°
154°
153°
NTAINS
Too-loo-uk
Colville or Kuny-a-nook R.
Nu-dru-yuk-puk
Chandler L.
MELVILLE
Ah-tiv-luk R.
68
Au-e-yuk
Shot-kak-uk
RILEY PASS
Ie-she-yuk
NAVY PASS
O-con-o-ne-look
Nim-yuk
My-o-ga-e-gal-uk
Caribou R.
NOTOARK RIVER
SCHWATKA MTS
Nim-yuk (Cottonwood)
Ko-to-ark R.
Singing-a-look R.
Nuk-luk R. (Owl R.)
Red Stone R.
E-vel-she-ark
Ambler or
Spoon
Greenstone
Kate
Jade
Bearbone
Bald
L.P.
1307
Hot Springs
Ah-lue-ga-mut
Kah-lu-look-to-ark (Big Fish) Walker R.
Ta-ka-hee-la L.
A-koo-look R.
Portage
37
Howard
Baird
3700
Now-kow-vik-hoy L.
Whale
Fort Cosmos
WINTER QUARTERS 1885-6
Kak-e-muta
L. Selby
Black R.
Now-get-to-ark (Gull L.)
Selawik
1172
Nub
102
PUTNAM RIVER
Par R.
Soo-look-to-mut R.
Ou-ka-lon-ka-gun R.
Ko-ka-thet-na R.
Al-lash-look R.
2834 Mt. Purcell
ZANE PASS
Ko-go-kl-nuk R.


SELAWIK L.
SELAWIK RIVER
Inland L.
Eschscholtz B
Chamisso I.
Good Hope Bay
C. Deceit
Buckland R.
Norton Bay
Mt. Bep
NORTHWEST ALASKA
Showing the region drained into
KOTZEBUE SOUND
by the
KUBUCK OR PUTNAM, NOTOARK AND SELAWIK RIVERS
and also
PART OF THE YUKON VALLEY
From explorations in 1885 and 1886 by the U.S. Naval Expedition
under the command of
Lieutenant George M. Stoney, U.S. Navy.
SOUNDINGS IN FATHOMS
HEIGHTS IN FEET
Statute Miles.
Nautical Miles.
Drawn on stone by R.F. Barnes.
163°
162
161°
160°
159°

LOCKWOOD MT
ZANE PASS
Ko-ka-chat-na R.
Al-lash-ook R.
2834 Mt. Purcell
KOYUKUK RIVER
YUKON HILLS
Melozikakat R.
NOWIKAKAT
Mt Hononila
YUKON RIVER
NULATO
Mt Benelaracher
66
65
158°
157°
156°
155°
154°

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

EXPLORATIONS IN ALASKA.

By GEORGE M. STONEY, Lieutenant, U. S. Navy.

(Continued from U. S. Naval Proceedings, No. 91, page 584.)

VIII.—THE NOTOARK RIVER.

From the reports of the two expeditions to the Notoark river, my own in December to the upper valley, and Mr. Reed's from below, the following description is made.

The Notoark, or the Inland river of English charts, rises in the same chain of mountains as the Putnam, Allashook, and Colville rivers. The head waters of all these rivers are not ten miles apart.

Like the Putnam, the Notoark has a delta, not so extensive, but very much like it; through it flow the five outlets of the river (only three of which are worthy of notice) which empty into Hotham inlet on the northern side near its connection with Kotzebue sound. The two most easterly outlets carry two fathoms over the bar; the most eastern, though narrow and winding, has little current. The mouth of the western branch is the widest, but yet has the strongest current. The inhabitants are not so numerous as on the Putnam; a few families live on the delta, and others in scattered villages around the headwaters. The many deserted villages on the lower portion of the river show that the natives are following the deer into the mountains. Its general direction is parallel to the Putnam from which it is separated by a range of mountains 3000 to 4000 feet high. The mountains on the northern side of the valley are less regular and not so continuous. The tributaries are few and unimportant. The river is full of sand bars and islands making navigation difficult; it is generally narrow, until about sixty-five miles above

its mouth, when it opens out to greater width for twenty miles up and becomes dotted with innumerable sand bars and islands. Here many hair seal come to breed where they are never disturbed by the natives. The channel is narrow and crooked, and the current rapid, to within fifty miles of the mouth, and when the river is swollen from the rains it is impossible to stem it; when the water is low it can be ascended since a foothold can be had for tracking. Although this river is like the Putnam, the current is much stronger, but both rivers are so affected by the height of the water that no approximate strength of current could be determined.

The Notoark valley is like the Putnam valley consisting of rolling tundra land with many high hills, interspersed with numerous lakes. The growth of timber, grass, etc., is also similar one hundred and fifty miles up; then the spruce and birch disappear and there remains only a scant growth of dwarf cotton-wood, willow and alder.

The Selawik River and Lake.

Selawik lake was first explored in 1884 by Ensign Purcell of my second expedition as described in his report. During the winter I explored the upper part of the valley with a party from Fort Cosmos. On July 16 I left Camp Purcell with a party to complete the work, which we did in eight days. The results of these expeditions are given on the chart and in the following summary.

The Selawik river rises in the mountains south of the upper Putnam and flows west to Selawik lake. Its valley is rolling but less so than the Putnam's and is interspersed with more lakes. The river is not so long as the Putnam or the Notoark, and its course is more winding. The current at the place where the river forks is .8 knots, and less lower down. Many tributaries enter from both banks; they are deep but of no great length. The banks of the Selawik are as regular as canal banks. Two fathoms can be carried up to the fork where there is a five-fathom hole; beyond, the water of the forks was too shallow for the "Explorer."

There are three outlets into Selawik lake; the westernmost is the deepest, two fathoms can be carried over this bar; over the others only a few feet. There is a fourth outlet into the smaller

lake "Inland" to the eastward of Selawik lake which is very shoal, not having over three feet of water in the deepest places and for the most part but one foot. There is every indication that this second lake was formerly part of the Selawik lake. Selawik lake itself is very regular in shape and depth. There is little animal life in it; it was dredged for hours, but no specimens were found.

On the Selawik river a little spruce grows in small clusters; more of it is found on one of the northerly branches. The principal growth is of willow and alder, the latter attaining considerable size. The river and lake were triangulated from July 17 to 24. The work was comparatively easy as the same mountain peaks used on the Putnam were visible from the Selawik.

Expedition to Jade Mountain.

On my first visit to Hotham inlet I noticed that the natives had a great many implements made of jade stone, and one man had a piece in the rough state. I inquired where they had gotten it and was told "on the big river" meaning the "Putnam" for which I was searching. When I discovered the river, and again asked about the jade, I was told it was further up.

On my second visit, the mountain where it was said to exist, was pointed out from the river, but the natives refused to accompany me to it, saying that they would never return—that only the medicine men could visit it, and then not until after a long fasting. I tried in every way to get at least one of them to go but without success. One man finally pointed out to me the best route, and I decided to take one white man and go anyhow.

On reaching the mountain I saw a green stone in large quantities; but it was so tough that only with the greatest difficulty did I succeed in chipping off some specimens with a cold chisel. These specimens were sent to the Smithsonian Institution, but proved not to be jade. In conversation afterwards, Professor Spencer F. Baird, then at the head of the Institute, told me that if I could find the jade deposit it would be one of the great discoveries of the age. So on my third expedition I determined to make a special effort to find it.

On July 27, 1886, I left Camp Purcell, Pipe spit, in the "Explorer" to visit the group of mountains which I had named Baird

and find the jade stone. I went up the Putnam to the point nearest the mountains, left the "Explorer" and started overland. The expedition consisted of myself, two white men, five natives, and three days' rations. The walking over the tundra was severe and the mosquitoes terrible both day and night. Owing to the recent rains the creeks were very much swollen and the party was obliged to swim across one. This stream, about thirty yards wide, was running at the rate of five or six knots in the middle with still water along the banks. I made a raft of theodolite legs and tent poles; and to make it more buoyant inflated our skin boots and tied them all around it. I then made a tow-line of all the odds and ends at hand, straps, ropes, etc. Those who could, swam over, temperature of water 38° F., the rest were rafted across, as were the stores, tied up in a rubber blanket. Later on, we forded another creek in water up to our waists. Much of the walking was through water knee deep.

On August 1, I reached the mountains and spent two days digging and looking for the jade. The entire spur of mountains was of green stone and amongst it I found the jade. I also found asbestos in the strata of the rocks. I saw only a few marks that indicated visits of the natives. I got a round of angles from near the top on one of the mountains. On the return, the coal vein discovered on my second trip, was visited. This coal was not good. Specimens of the rocks and coal were forwarded to the Smithsonian Institute. The road back was less irksome as the water had fallen so that all streams were fordable. August 3 I reached the "Explorer" and August 7 reached Camp Purcell, Pipe spit.

Prof. Thos. Wilson, Curator, Division of Prehistoric Archæology, U. S. National Museum, Mr. J. R. Bishop and Prof. Geo. F. Kunz, of New York, have taken great interest in this jade deposit. The former has written the subject up in his article on jade.

IX.—Expedition to St. Michael's and return, under Passed Assistant Engineer A. V. Zane, U. S. N.

In obedience to orders, Passed Assistant Engineer Zane left Fort Cosmos on December 26, 1885, en route to St. Michael's, via Nulato. The party consisted of himself, Socoloff (W. R. S.), Riley (interpreter), Suan (native guide from the Yukon) and

Suan's son, a boy of eighteen years. They carried a complete outfit and provisions for fifteen days, on two sleds, one load weighing three hundred and seventy-nine pounds and the other two hundred and forty pounds which were drawn by twelve dogs. A third sled belonging to Suan and his son was drawn by five dogs.

The trip was made as directed. It took twenty-seven days to reach St. Michael's and nineteen days to return. The following is a summary of each day's journey as reported by Mr. Zane. All courses are per compass.

December 26, at 8.55 A. M. left Fort Cosmos and arrived at Kallamute. Traveled the usual route along Putnam river; found snow too deep for easy progress. Distance made, good twenty-eight miles. December 27, left Kallamute. Road easier; less snow. Traveled along the river; noticed many open places in the ice along the left bank. Quartered at Iyak, just below Par village. Distance made, good seventeen miles. December 28, left Iyak, having bought dried fish for dog food, and quartered at Par village, five miles beyond, where we remained next day repairing damages. December 30. Left Par. Shaped a S. E. by S. course following generally the Par river. Road good owing to recent travel by trading natives. Encamped on left bank of the Par. Distance traveled about seventeen miles; made good on course twelve miles. December 31. Broke camp. Stood S. E. along the Par for one mile, then E. S. E. leaving the river and taking a road over the tundra. The Par at this point made a large bend to the westward, and then to the eastward, by south. Found the country level and indented by numerous lakes from one hundred feet to a couple of miles in diameter and considerably below the level of the surrounding land, making the getting on and off the ice heavy work. Reached a deserted house and spent the night. Distance traveled about sixteen miles; good, twelve miles.

January 1, 1886. Shaped the same course, E. S. E. Road as before though over fewer lakes. Crossed the Par river three times; informed by guide it would be met no more as it made off to the eastward. Weather intensely cold; thermometer reading −70° F. at 3 P. M. when camp was made. Distance made good fourteen miles. January 2. Broke camp. Course E. S. E. Road level, through dense spruce forests intersected by many

small streams and lakes. Mountain ranges lay on the right hand running northwest and southeast and distant five miles. The road led around their southeast end. Went into camp. Distance made good fifteen miles. January 3. Broke camp and took a S. E. course. Road through dense forests requiring great care in steering sleds. After going eight miles made the Koyukuk or Tug-ga-rag-a-wick river; changed course to S. W. by S. to follow the river, a fine stream about a mile wide with high, thickly wooded banks. Reached a native house and went into quarters. Found the family, a father, mother and two children starving; gave them food. Distance traveled about twenty miles; made good on S. E. course eight miles; on S. W. by S. course, seven miles.

January 4. Under way. Course S. W. Road generally good over tundra; crossed several lakes and tributaries of the Koyukuk. Quartered in a native house. Distance traveled about twenty miles; made good, fifteen miles. Bought fish for dog food. They were from three to eight inches long, fat and oily, and abounded in the small streams of the tundra. The natives roast them on a stick stuck in the ground and inclined towards the fire. As they thawed they apparently regained life and squirmed and moved until roasted to death. They tasted of the tundra. January 5. Under way. Stood S. by W. Road very bad in places and frequent detours were made. Passed a house two hours after starting. Struck the Koyukuk river and journeyed on it. Reached a house and went into quarters. Wind blowing a moderate gale from N. E. Distance traveled twenty-eight miles; made good fifteen miles. January 6. Under way. Course S. S. E. Road as usual through forest and brush and over tundra dotted with lakes. Made the Koyukuk again opposite a small tributary which was followed for seven miles when the house of Suan the guide was reached where the party quartered. Distance traveled twenty-eight miles; made good fifteen miles.

January 7. Remained at Suan's, a well-built hut of logs, containing three rooms, crowded with dirty natives, good natured and obtrusively helpful. Repaired damages and rested dogs. Bought dog food so as to give two fish apiece per diem, one not being sufficient for the heavy work in hand. Paid the following prices: A hand of tobacco for six fish; a block of matches for three fish; a tin of powder for ten fish; one box of caps for seven

fish. Tea, needles, thimbles, etc., were also good trade articles. January 8. Left Suan's. Course S. W. by S. Left the Koyukuk, which here made a big bend to the westward, and crossed a hill 500 feet high. Thence the road led over a succession of lakes separated from each other by wooded tracts from one hundred feet to a quarter of a mile in width. Made camp. Distance traveled eighteen miles; made good fourteen miles. January 9. Broke camp and stood S. by W. Snowed all day, making the road very heavy. Found broad iron runners of big sled a great impediment. Encamped, having made fifteen miles. January 10. Broke camp. Course S. by W., over tundra and through forest and brush. Road heavy from recent snow. Reached a native house on the Koyukuk river and quartered. Distance traveled eighteen miles; made good fourteen miles.

January 11. Under way. Course S. S. W. Soon met a small stream; followed it until the Koyukuk was met, down which we traveled until it met the Yukon, a broad, beautiful river with a large bend where the Koyukuk entered it. On the right bank, five miles from the mouth of the Koyukuk, a peak, 1500 feet high, called Be-ne-le-rah-cher (big mountain) rose abruptly from the water; the sides sloped one-third the way down and then fell perpendicularly to the water. Along the right bank of the Yukon was a mountain range, thickly wooded with spruce; along the left bank the wood was poplar and cotton-wood. In the center of the river, here two miles wide, lay a large island; and for fifty miles down these constantly succeeded each other. Reached a good house called the "Big Mountain house," just below the Be-ne-le-rah-cher, kept by a prosperous native. Went into quarters. Distance traveled twenty miles; made good sixteen miles. January 12. Left Big Mountain house. Course S. by W. ½ W. over hard snow. Reached Nulato, one-half mile above the Nulato of the time of the Telegraph Company. Went into quarters in the house of a native trader named Philka, where we were treated royally and furnished all I was short of. Distance made good twenty miles.

The storehouse of the Alaska Commercial Company was closed though Philka had charge of a few trade goods. Nulato, besides the company's store, had four well-built log houses, clean and comfortable. Modern stoves were used and other conveniences. In Philka's there was a mess-table with china, etc., and good

food, which I enjoyed, having been short for several days. January 13. At Nulato. Overhauled sleds and gear and rested dogs. Borrowed three big, strong dogs to help on large sled. One native here spoke good English.

January 14. Left Nulato. Course S. by E. on the Yukon. Road heavy from new snow. The new dogs, apparently part Newfoundland, proved much superior to the others. Reached the house of a celebrated old native called Tehunka. In 1851 he traveled eighty miles in one day on snow-shoes from Nulato to St. Michael's, carrying the news of a massacre of the whites at Nulato by the Koukuks. Hired him for fifty pounds of flour to act as guide to St. Michael's. Bought fish and quartered at Tehunka's. Distance traveled twenty miles; made good seventeen miles. January 15. Left Tehunka's. Course S. by W. on the Yukon. Bought for a box of caps a pair of wooden runners three inches wide and lashed them on the iron runners of the big sled. Found them a great help, relieving the dogs of much strain. Road good enough though snow was deep and soft. Quartered at a native's, name Kaltaga. Distance traveled twenty miles; made good seventeen miles. January 16. Left Kaltaga's. Crossed the river and started on course S. S. W. ½ W. through a level valley three miles wide intersected by numerous small streams; over tundra and through spruce forests. Road covered with snow. Found the way by walking ahead and sounding with poles. Had to tramp down the snow to make a path for the sleds. Encamped, having traveled eighteen miles; made good thirteen miles. Before starting across tundra it is necessary to take plenty of dog food. January 17. Broke camp. Course S. S. W. ½ W. Road good one-third the way, over tundra; bad through forest and brush. Encamped, having traveled eighteen miles, all good.

January 18. Broke camp. Course S. S. W. ½ W. over same kind of road. At 10 o'clock reached Beaver house on Beaver lake. At 4 o'clock reached the base of Vesolia Sopka, a mountain 2000 feet high with a triangular top and square base. It marked the intersection of the valley in which the road lay, with another running to southward and eastward. The Unalaklik river rose in the second valley, crossed the first valley at this point, and ran along the northern side, emptying into Norton sound. The road from this intersection lay along the foot of

the mountain over tundra covered with good, hard snow. Reached Ulukuk on the Unalaklik, a clean, well-built village of three houses, and went into quarters. Distance traveled thirty-five miles; good twenty-six miles.

January 19. Left Ulukuk. Course S. S. W. ½ W. Road over tundra until noon. Then made the Unalaklik and traveled on smooth ice. Found iron runners better than wood for ice. Dogs had hard work, slipping continually. Left one dog on the ice completely worn out. Reached the village of Unalaklik at the mouth of the river facing Norton sound. Went into comfortable quarters at the house of Zulaluk of the Alaska Commercial Company. Distance traveled twenty miles; made good thirteen miles. This village, the largest on Norton sound, comprised fifteen dwellings and a dance house or Cazeem. Forty-five miles to S. S. W. the mountain of St. Michael's loomed up. Offered a reward of five skins for the thermometer lost a short time before arrival. Had sealskin soles put on boots, deerskin being unfit for ice or wet snow. Bought provisions. Exchanged Socoloff's sled for a better one shod with whalebone. January 20. Under way. Course, south. Norton sound being open, took a road on the ice skirting the shore. Crossed over Tolstoi point. Made Nu-wayn-yuk, on a river of the same name, called also by its Russian name Galtzora. Went into quarters. Distance traveled twenty-five miles; made good sixteen miles.

27th day, January 21. Course S. W. ½ W. Road good over ice. Passed the village of Keg-ich-tow-ik, and at 1.15 P. M. reached St. Michael's. Distance traveled twenty-five miles; made good seventeen miles. Went into the hospitable quarters of Mr. Lorentz, the Alaska Commercial Company's agent. Next day the guides, with ample provisions of flour, hard bread, sugar and tea, were sent back; Suan to be ready at Nulato for return trip. Purchased for $18.00 a new, well-constructed sled, made of ash, and for $8.00 new, halter girt-line harness for dogs. The large sled and gear were condemned, being beyond repair. Got provisions for return trip, paying only for such articles as flour, tea, tobacco, etc. Beans, rice, butter, canned goods and trade goods, etc., were given, as much had to be declined for want of storage-room. Procured a maximum and minimum thermometer from Mr. Clark, the U. S. Signal Service observer; and borrowed a dog from Mr. Lorentz. The greatest kindness and

assistance were universally met with. Remained seventeen days at St. Michael's, having been detained three days by heavy gales.

On February 7, the return trip of nineteen days was begun. At 10.30 left St. Michael's. Found the sound frozen, so headed direct for Nuwaynyuk. Road heavy from fine particles of frozen snow and salt slush, offering a resistance like sand and gravel. Reached Nuwaynyuk and went into quarters. February 8. Under way for Unalaklik where quartered. The road over the ice was better. Shot a dog who had gone lame and became worthless. Found the lost thermometer and paid the reward. Got back Socoloff's sled thoroughly repaired as ordered. February 9 and 10. Left Unalaklik direct for Ulukuk. Road in fine condition. Crossed the portage, sleeping out one night. February 11. Left Ulukuk. Made the Yukon river at evening. Crossed it, and quartered at Kaltaga's. Broke runner of Socoloff's sled, repaired it temporarily.

February 12. Made Nulato by nightfall and quartered. Found Suan, the guide, waiting. Feb. 13 and 14. Remained at Nulato resting. Bought a new sled for $10.00 to replace Socoloff's. Got natives to draw a chart of the Koyukuk river with tributaries, and the Par river, showing the portage from one to the other used in the summer trips to the Putnam.

Old Nulato, where the massacre of 1851 took place, was visited under the guidance of Kargarine. The only building remaining was that of one of the party of the Western Union Telegraph Company occupied in 1867 and 1868. Saw the grave of Lieutenant Barnard. The headboard was upright: on it, surmounted by a cross, was the following:

Lieutenant James J. Barnard,
H. B. M. S. Enterprise.
Who was killed near this place
by the
Koukuk Indians
Feb. 16, 1851. F. A.

February 15. Left Nulato. Traveled on Yukon. Passed the Big Mountain house and made the Koyukuk river. Quartered in a native house. February 16. Under way; but soon went into quarters, Sucoloff having rheumatism and unable to walk. February 17. Under way. Road over tundra good.

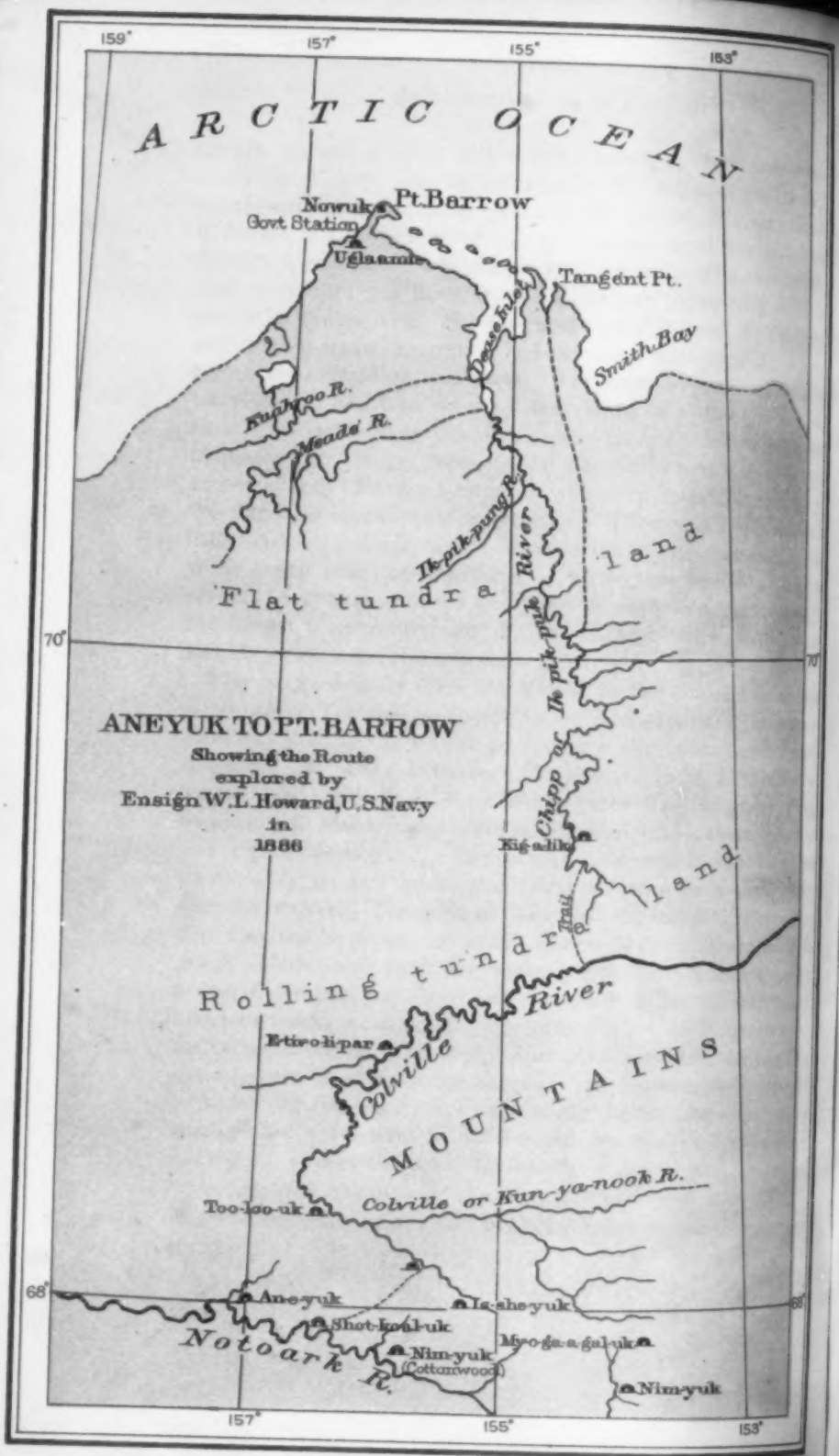
Went into camp at nightfall. February 18. Traveled all day following regular road. Reached Suan's house and quartered. February 19. Remained at Suan's. Repaired damages; hired three dogs and bought dog food. The road over the mountains was decided upon in preference to following the regular route, in spite of guide's objections.

February 20. Left Suan's house. Followed road which was good. Went into quarters in the native house used on the outward journey. February 21. Started on the route across the mountains. Course west. Followed the Koyukuk a little while and then struck across. Road good, over many lakes and small streams. Made a short cut from the road to reach a deserted house, where quartered. Distance traveled twenty miles; made good fifteen miles. February 22. Under way. Course N. by W. over the mountains. Road heavy over tundra and through forest and brush, a way having to be made. Reached the top of foot hills overlooking the valley in which the road lay. Encamped in valley. Distance traveled twenty-five miles; made good eighteen miles. February 23. Broke camp. Course N. W. by W. over tundra, with little snow, and hills 500 feet high with gentle southern slopes and steep northern faces. A stream wandered through the valley and on its banks grew the only wood to be had. Encamped, having made good twenty-five miles. February 24. Broke camp. Course N. W. by W. five miles; then N. by E. ten miles. Reached the head of the valley, forty-five miles long and eight to ten miles broad, running north and south. The mountains on the eastern side rose from 1500 to 2500 feet high; on the western side they were lower. Started over the mountains, course N. W. Road heavy over hills 800 to 1000 feet high. Made camp. Distance traveled thirty-five miles; made good only twelve miles.

19th day, February 25. Broke camp. Course N. W. over the mountains. From the summit overlooking Putnam river, saw Fort Cosmos bearing W. N. W. Killed a worn-out dog. Came on the Putnam river ten miles above the Fort, and reached Fort Cosmos at 7.55 P. M. The route to St. Michael's was that used by the natives in their winter trading expeditions. It led along the Putnam river fifty miles to the Par, up it forty miles to a portage of twenty-five miles, through dense spruce forests, to the Koyukuk river; down this fifty miles; next, forty miles across

tundra, a chain of lakes, and through forests to the Yukon river; down the Yukon, seventy miles; then fifty miles of tundra with occasional thick spruce growth, to the Unalaklik river; fifteen miles on it to Norton sound; and finally thirty-five miles on Norton sound and St. Michael's was reached. The road to the Yukon country via the Par, is an old one extensively used in winter by the natives. For the most part it is good, well defined and easy of travel, though it had been but little used the winter before my expedition went over. The route over the mountains traveled the last four days of the return trip, though a trifle shorter to make Fort Cosmos, is seldom used, is not so short to reach Par. Stops were generally made in tenanted huts and dog-food bought of the occupants, who were hospitable and made the party as comfortable as possible. They nearly all spoke a little Russian. Some nights were passed in the open air, seven while going, and less returning. The weather was of all kinds; several heavy snow storms and gales of wind were encountered; the lowest temperature –70° F., the highest 30° F. All hands and the dogs stood the trip well.

The summer route from the Yukon to the Putnam is up the Koyukuk or Tug-ga-rag-a-wick to the Kokachatna; up it a short distance; then a day's portage carrying the canoe; and finally down the Par to the Putnam. The journey to St. Michael's required twenty-seven days including three days of rest. Four hundred and ninety miles were traveled, of which three hundred and eighty were good. The actual time under way was one hundred eighty-two hours and thirty minutes or a little more than seven days. The average daily distance traveled was twenty and four-tenths miles, of which fifteen and eight-tenths were good. Under way each day seven hours thirty-five minutes at a speed per hour of three and one-tenth miles, of which two and four-tenths were good. The return trip took nineteen days, including three days of rest. The road was fine, having frequently been used since the trip out. In fourteen days traveled two hundred and twenty-five miles along the old route, then stood across, taking five days to make about one hundred miles good, averaging twenty-six and one-fourth miles a day, of which seventeen and a half were good; under way nine hours twenty minutes each day at a speed of three miles, of which two were good.


159°
157°
155°
153°
ARCTIC OCEAN
Nowuk
Pt. Barrow
Govt Station
Uglaamie
Tangent Pt.
Smith Bay
Kuukpuk R.
Meade's R.
Ikpikpuk River
Flat tundra land
70°
ANEYUK TO PT. BARROW
Showing the Route
explored by
Ensign W. L. Howard, U.S. Navy
in
1886
Chipp or Ikpikpuk
Kigalik
Rolling tundra land
Trail
Colville River
Etivolipar
MOUNTAINS
Too-loo-uk
Colville or Kun-ya-nook R.
68°
Aneyuk
Is-she-yuk
Shot-kook-uk
Notoark R.
Nim-yuk
(Cottonwood)
Myo-ga-a-ga-luk
Nim-yuk
157°
155°
153°

X.—Expedition to Point Barrow under Ensign Howard.

In accordance with the arrangement made with Owpuk at Issheyuk on my visit to that place in December, I started a party out on April 12 to join the natives at Issheyuk and go with them down the Colville to Point Barrow. Ensign Howard who accompanied me on my trip, was placed in charge of the expedition and I assured him that I would not leave the country until I knew that he was all right; and that I would leave provisions at Fort Cosmos in case he should return after our departure. The trip occupied ninety-six days, from April 12 to June 16, and the account of it is here given in his own words.

April 12, 1886, I left Fort Cosmos with Price (C. M.), Riley, the interpreter, and two natives, en route to Point Barrow. The expedition started with two sleds and outfit weighing 485 pounds and 432 pounds, and 15 dogs. Passed Assistant Engineer Zane with one sled and seven dogs accompanied the party to Notoark. The outfit consisted of the following articles: *Provisions*, 25 lbs. flour; 25 lbs. bread; 25 lbs. corned beef; 4 lbs. tea; 50 lbs. sugar; 15 lbs. lard; 3 lbs. baking powder; 10 lbs. salt; 20 lbs. pork; 1 bottle pepper. *Cooking Gear*, 1 frying pan; 1 camp kettle; 1 small kettle; 1 tea pot; 2 tin cups; 3 tin pans; 2 forks; 2 spoons; 2 small axes; coal oil stove and feeder; 5 gallons coal oil. *Clothing*, 2 suits underclothing; 2 pairs trousers; 4 pairs socks; 6 handkerchiefs; 2 towels; 3 pair boots; 2 blue shirts; 2 hats; 1 sleeping bag and sleeping socks; 1 parky; and 1 pair blankets. *Instruments*, 1 sextant; 1 chronometer watch; 1 artificial horizon; 2 note books; 1 pocket barometer; 1 spirit thermometer; 1 spy glass; 1 compass. *Medical outfit* as made for the Greely Relief Expedition. *Arms and Ammunition*, 1 shot gun with 200 cartridges for same; 1 Hotchkiss rifle, 300 cartridges for same; 2 revolvers, 50 cartridges for same. *Trade Articles* for purpose of paying natives, 50 lbs. leaf tobacco; 8 lbs. lead; 12½ lbs. shot; 17 boxes caps; 8 knives; 10 papers needles; 12 thimbles; 12 combs; 6 bundles matches; 6 packs cards; can of beads; 3 pipes; 10 lbs. powder; 6 snow goggles; 6 files; some match-rope and snappers; and 150 lbs. dried fish for dog food.

The Nutvucktowoark river was reached the first day after a hard journey over almost bare tundra and over lakes and streams the ice of which was covered with water. Made camp where some stuff had been cached on the previous reconnoitering trip.

Found the cache unmolested. Natives had been near but had camped a little to one side to avoid disturbing it. The next day made the Evesheark river and camped near Camp II of the previous trip. Found cache undisturbed. This river is a tributary of the Nutvucktowoark river. April 14, camped at old Camp III on the mountains in a native snow hut made of blocks of snow cut from a packed snow drift and piled around a circular base to a height of a few feet, the roof formed by overlapping the higher layers. Upon becoming warm the moisture congeals upon the snow inside which keeps them dry. These huts are found all through the mountains, being made early in the season and through the winter by hunting parties. At this camp my natives went off deer-hunting. April 15, made Koolooguck and learned that Owpuk, the native with whom I intended traveling to the coast, was still at Issheyuk. The deer hunters returned, bringing five deer. April 16, left the village and reached Aneyuk on the Notoark river, distant about ten miles N. W. (p. c.). Found the guide of my former trip, Ashewanuk, who said Owpuk was not at Issheyuk and that the village was deserted. Hired this guide to help me find him. Aneyuk is the highest point on the Notoark river reached by the natives in boats. In the fall they come here and wait for the snow to sled into the interior. The skins of the boats are cached until the next season and their frames are placed on high racks to prevent animals eating the lashings. In the spring the people come down by sleds to Aneyuk, put together their boats, and go by water to the coast. This custom is general, only a few families remaining in the mountains. April 17, left Aneyuk and arrived at Shotcoaluk twenty miles distant N. E. (p. c.) where I remained until the 20th on account of a heavy wind storm that filled the air with fine snow obscuring the nearest objects. Here I received one hundred pounds flour that had been sent ahead. April 20, left Shotcoaluk for the mountains. The snow drifted so the leading dogs could not be seen, and everybody suffered from the piercing cold. Connected all the dogs and sleds in line ahead and made for the nearest valley, clinging to the sleds to avoid getting lost. Finally went into camp in a shelter cut out of a large snow drift. April 21, left this camp; made about 12 miles north (p. c.) and reached the Etiviuk river whose headwaters are at Issheyuk and which helps form the Colville river. The village, twenty miles west (p. c.) of Isshe-

yuk, contained one family, and I was informed that all the natives had gone down this river and were encamped below. April 22, started down the Etivluk; came to a deserted village and was disappointed in not finding Owpuk. Continued on and reached the village of Tooloouk where I found him. The natives seemed glad to see me and sent dogs to help as soon as we were sighted. There were ten houses in this village and seventy natives; but this number varied, as people were constantly coming and going. After a long talk with the natives, Owpuk consented to take me to "salt water". In the meantime a special hut had been built for myself and party, out of poles stuck in the snow with their upper ends bowed and lashed together and over this frame was put a cover of sewed deer skins. At this place I discharged my new guide and sent back the two natives brought from Fort Cosmos, with a large sled and eight dogs, and a written report of my trip up to date.

We spent a week at this village situated in a deep valley just off the Etivluk river. On the hills above, natives were always on watch for deer, and when sighted, all the young men would leave for them. A number were killed which the women brought in, dressed and prepared. All the work in the village was done by the women; they sledded for and gathered the scarce wood, cooked the food and took it to the men who generally eat together sitting around in a circle. They eat ravenously until everything is gone, there being no apparent limit to their capacity. It is also wonderful the fatigue and exertion they can undergo without food or sleep, recuperating by eating and sleeping alternately for several days. These natives had immense bundles of skins to trade on the coast for seal oil, rifles, etc., the natives on the coast depending on them for their skin clothing. The skins are dried and kept in bundles outside the houses, except wolf skins which are hung from poles at some distance from the village, as a charm against disease. Whenever the sleds stopped the wolf skins were first taken off and hung away as above. A grand dance took place which I attended. This was a rehearsal in preparation for the dance upon meeting the Point Barrow natives. May 1, twelve sleds, including mine, left Tooloouk. Each sled averaged four natives and four dogs. Some were bound down the Colville river and some down the Ikpikpuk. Stopped twice to get deer and learned that the long wait at Tooloouk had

been to allow the deer to get ahead as they depend upon them for food. All the deer killed were covered with parasites which the natives eat greedily. May 2, under way; making frequent stops to allow the old people to catch up. All hands traveled on snow-shoes, the sleds being too heavily loaded for any to ride. Sighted a large herd of deer and encamped, having made about twelve miles N. W. (p. c.). Eight more sleds arrived from Toolouk, having left the day before. The mountains passed this day were lower than those at Issheyuk (showing evidence of their limit) and irregular in shape, and rocky. May 3, in camp waiting for four more sleds from the mountains. These new arrivals were strangers to me. I was advised by a native to distrust Owpuk; this was the only instance I ever met of one native speaking ill of another. May 4, under way, and made about fifteen miles N. by W. (p. c.) avoiding long bends in the river by crossing the tundra where the women gathered berries. These ripened in the fall just as the snow comes; they then freeze on the bushes and are thus preserved until the snow melts down in the spring. We gathered a great many and I found them especially good, their effect being that of a mild laxative. During the forenoon passed a hill about 500 feet elevation with out-croppings of coal. On the sides of this hill beyond the coal were also found large pieces of a substance called wood by the natives; it was hard, brittle, light brown in color, very light in weight and burned readily, giving out quantities of gas. This material was scattered about in all shapes, sizes and quantities. The snow and ice made it impossible to climb and dig; a specimen was preserved. May 5, under way, and made ten miles N. by W. (p. c.) when went into camp on account of strong gale from the westward which blew so hard the dogs could not pull against it. The driving snow covered my glasses, making it impossible to see, so took them off and in the evening suffered from an attack of snow blindness that lasted all night. The natives suffer a great deal from this source. Their only cure is the shaman who beats a tomtom and paints a circle around the eyes with a black paint made of ashes and seal oil, giving the appearance of having on glasses; as the eyes water a great deal, this pigment soon gets all over the face. This camp was at the limit of the mountains; on all sides and ahead was undulating land. May 6, under way, making frequent stops; made about six miles N. by W. (p. c.). During the day

an addition was made to the party in the form of a baby boy. A place was hollowed out of a snow drift and a couple of deer skins put in. The caravan then continued on leaving the woman behind alone. Towards evening the mother with her infant came into the camp, having walked a distance of three miles.

May 7, under way. Made about twelve miles N. by W. (p. c.), when reached the village of Etivoli-par. This is situated at the point where the Etivuk river flows into the Kungyanook, or Colville river. At this place those who go down the Colville river leave their boats in the fall and wait for snow to sledge to the mountains. Most of the natives with whom I was traveling remained here waiting for the ice on the Colville to break up. The woman with the baby had hard work to keep up; upon my offering her a ride the others interfered, saying she must go on foot; she also had to make her own fire, cook her own food and use her own special utensils; according to their superstitions to do otherwise would result in misfortune to the child. May 8 to 12, remained at the village, during which time it was either snowing or raining. The natives opened their caches made last fall, and deer meat and fish were taken out frozen solid and in perfect condition. On May 11, the first goose of the season flew over, the natives were very jubilant and by imitating the goose's call kept it circling overhead several minutes. I was not allowed to shoot it. Natives here brought me a small mammoth tusk, but I left it on account of my load and their telling me there were plenty on the Ikpikpuk.

May 12, eight sleds, including my own, started for the Chipp or Ikpikpuk river, going on down the Colville. One native took his boat on his sled and started with us, evidently going down the Ikpikpuk on my account. Those left behind appeared very sorry to part with us and tried again to persuade me to go down the Colville. Made about twelve miles N. by E. (p. c.). Found the Colville to be a very winding river with steep banks on this day's run, varying in width from 400 to 1000 yards. It appeared to be shallow and was filled with islands with a very heavy growth of brush. At camp that night the natives dug roots called mashoo, they were very succulent and tender, and later on formed my principal food. May 13, remained in camp. Sent ahead part of outfit and cached it, following the example of the natives. May 14, under way. Picked up cached stuff and continued on;

made twelve miles N. by E. (p. c.). Sighted a herd of deer near camp and shot five. Country undulating; river, wide and tortuous, sometimes turning at right angles, filled with brush-covered islands; banks steep, in places 300 feet high. May 15, in camp. Women sledged for deer killed the day before. Sent part of load ahead and cached it as before. Got six deer during the day.

May 16, under way; made twelve miles N. E. (p. c.) and reached the last camping-place on the Colville river. The character of the country and river as on previous day. From this point, according to the natives, the river trends N. E. (p. c.). May 17 to 20. In camp, detained by the snow-blindness of the natives. I gave them an ointment of vaseline and laudanum which I had found beneficial. The shaman did his duty by shouting and beating the tomtom. Sent load ahead as before. May 20, under way. Made six miles N. N. W. (p. c.) to the top of the hills, then changed course W. N. W. (p. c.) for six miles and camped on a small creek emptying into the Ikpikpuk. May 21, in camp. Sent part of load ahead as before. May 22, under way. Made ten miles N. W. (p. c.) and went into camp on the Ikpikpuk river. According to custom, sent native ahead to announce our arrival to the rendezvous below, where the natives from the mountains were assembled to start down the Ikpikpuk river. During the evening some of them came up to meet us and showed great curiosity at my presence, but all were kind. May 23, under way. Made the rendezvous village of Kigalik, consisting of thirty tents and one hundred and fifty natives. Just before arriving at Kigalik, came upon the racks holding the boat frames, and each native examined his to see that it was all right. Counted eighteen oomiak and twenty kyak frames. Under the frames was a cache containing the boat covers. As we neared the village our party was met and assisted with extra dogs and escorted to the lower end of the camp which had been reserved for us. In the center of the village a large dance house had been made by sticking poles into the ground and hanging skins over them, everyone furnishing a few skins. In this house the men worked at new boat frames during the day and all hands danced at night, their food being carried there by the women. The latter spent their time in tanning skins and making clothing. The wood for the boats came from the rivers to the southward, passing through

many native hands. The boats are lashed with strips of whalebone; the oomiaks are covered with sealskin and the kyaks with deerskins.

May 24 to 30. In camp at Kigalik. Natives building boats, similar to those on the Putnam, and making preparations for descending the river. Children gathered berries and wood, and shot ptarmigan with bows and arrows. Some of the men gathered poles for tents, to be used in trade at Point Barrow where only drift-wood can be got. At this place the last green brush was seen ten to twelve feet high. After this fires were made from grass and creepers with a little coal-oil. A lookout was always kept for deer and all work suspended to pursue them. Flies made their appearance, and geese, ducks and ptarmigan were becoming plentiful, the latter commenced changing their plumage. Two mammoth tusks were brought me weighing about one hundred and fifty pounds each, one foot in circumference and ten feet in length. I was told of another too large to be lifted. There are many superstitions regarding their removal. I was never allowed to have mine in camp, nor even to touch it, until I arrived at Point Barrow. These tusks are found in the spring while going down the river; the water rising washes away the icy earth of the banks and shows the tusks firmly embedded. The natives cut them up into two-pound pieces and trade them on the coast. No inducement will make them take a whole tusk. They make handles, dippers, fish-hooks, etc. out of this ivory. The fish-hooks are made from a small piece six inches long, with a sharp pointed piece, an inch in length, lashed to one end at an angle of 45°. These hooks are baited with deer meat and set all along the banks where they are visited twice a day. Made a sledging trip to the headwaters of the Ikpikpuk river. It is formed by the junction of several smaller streams which drain the hills between it and the Colville. From the top of the highest hill on the river (500 feet), I got a good view of the Ikpikpuk.* It is tortuous in the extreme, bending and doubling upon itself in a remarkable manner. During my absence the natives had made all preparations for starting down the river, boats were covered, sleds put away, etc. I gave my sleds and dogs to Owpuk.

*I renamed this river the "Chipp," after Lieut. Chipp, who was lost on the Jeannette expedition.

June 2 to 8. In camp at village. The ice began breaking and the river rising. The high water forced everybody to leave the quarters on the spit and move into the interior. Many natives moved only a foot or two at a time. The shamans gathered at the bank and would stick their knives at the water's edge to prevent any rising beyond it. Each failure was greeted with derisive laughter as the discomfited medicine men stepped back and picked up their submerged knives. Instead of dancing in the evenings the favorite amusement now was tossing in the sealskin blanket. The river rose six feet by June 6, and then commenced falling. Boats were got ready and all stuff not needed on the journey was cached. June 8, left Kigalik, five oomiaks starting, and made about fifty miles down the river. Just before camping passed a small creek coming in on the left which was stated to be very long. The boats are loaded and handled very skilfully; poles are stuck along the sides to keep the load in place, which is piled four feet above the gunwale. Some heavily loaded oomiahs have kyaks lashed each side to insure stability. The owner steers from the stern, the family sit in the bow and paddle with short handled broad bladed paddles. Each boat has a long handled narrow bladed oar which the women pull, using a hide oarlock. Stopped often to get mashoo root for food, and killed three deer at the last stop. Upon reaching camp the boats were discharged and turned up to dry. This rule was always followed, and occasionally they were well rubbed with oil. June 9, in camp. The country was rolling land with small berry-bearing bushes here and there. The kyaks with the young men hunters went on ahead to secure food. June 10. Under way, and made about twenty miles. Passed a small creek coming in on right side, and camped on left bank of the river, just opposite the mouth of a large tributary. This day the Ikpikpuk averaged four hundred yards in width and fourteen feet in depth. The country was more open, and hills lower. Food was becoming scarce as the herds of deer scattered over the open country and the game kept to the lakes instead of the river. June 10 to 14. In camp, detained by a heavy gale from the southward and westward. It blew steadily for three days, then became squally, hauled to the northward, and died out. Caught our first fish; native name Tee-tal-uk, scientific name, Lota maculosa. I learned that in going down only a few boats went

together as enough food could not be provided for all hands at the same time. Their principal food now was the seal meat and oil which had been brought up the previous fall and cached. The young men were out after deer all the time. The dogs were fed on bones and pieces of deer skin with the hair soaked in seal oil. Sighted a few deer, all hands started after them, some going barefooted over the snow and ice tundra, but none were killed. June 14, under way; and made about twelve miles; stopped on account of heavy snow storm. Passed a small tributary coming in on the right side. The surrounding country was now changed to a level waste of tundra with an occasional mound-shaped sand-hill from 50 to 100 feet high. The river banks were low and of sand, on top of this was a network of roots. Low brush grew in scattered places. From this point no rocks were met with, hence all the boats carried stones to crack bones upon.

June 15 to 19. In camp; detained by bad weather. The snow was all gone so the deer had to be brought in on dogs saddled with sealskin bags or blankets placed over the back and tied around the neck and under the belly. These contained pockets on both sides in which the dressed deer meat was put. Two dogs can carry a deer. I noticed a great number of sick people, especially women and children who appeared to have severe colds. I gave them medicine and as they all recovered I was always consulted. June 19, left camp and continued down the river making about thirty miles. Passed a small tributary coming in on the right side. River wide and shallow with less current. Country flat, low and sandy, with occasional small sand mounds and a growth of stubble. Caught two white fish, native name, See, scientific name, Stenodus Mackenzie. June 20, under way and made about twelve miles. June 21 to 23, in camp, detained by sick people. The natives could not shoot game on this account and I was asked to do it. Only wooden bowls could be used in dipping water from the river as to use metal pots would cause the fish to leave. The fish caught here were dried and kept for future use as they became less plentiful lower down. June 23, under way with one other boat, the remainder being detained by sickness. Made about thirty-five miles. At this point the river divides into two branches. We took the left; was told by my guide both went to salt water, the right branch farther to the eastward. The left branch was about one hundred yards

wide at starting, soon increased to about five hundred yards, very shoal in places and filled with sand-spits and sand-islands. Banks so low that during freshets the river flows over the tundra. Game getting still scarcer, remaining further in the interior.

June 24, under way and made about thirty-five miles. Banks of river so low as to be scarcely perceptible. Passed through two lakes made by the river widening over the tundra; the first nearly circular and about a mile in diameter; the second, half a mile further on, was about five miles in diameter. Both were very shallow (the boats grounded in the larger) and were full of sand-spits and islands. The surrounding country was level and a network of ponds and lakes of all sizes, with the river winding in and out among them connecting a great many. While crossing the second lake we sighted two tents of Point Barrow natives which caused the wildest excitement, the natives paddling their hardest, and shouting with all their might, although the tents were several miles away. I came to the conclusion from later observations that these people are afraid of the Point Barrow natives, though they have never harmed each other. The paddling and shouting were kept up until we reached the tents. These Point Barrow natives were filthy in appearance and condition, their clothing being covered with grease and oil. As soon as we landed they brought us whale and walrus blubber to eat which even the dogs refused, though the natives ate it with apparent relish. Their language I could not understand at first, the words seemed the same but the pronunciation different, being short and jerky, like that of the Yukon people. These natives had left Point Barrow a week before and were at this place to hunt deer and fish. We camped near these tents and the natives began visiting us. These people were on their way to the Colville and Mackenzie rivers, and crossed the tundra to meet us. They were making their way along the Arctic coast with dogs, sleds and boats, carrying the boats on sleds over the ice until they meet water. The trip from Point Barrow to Mackenzie river and return occupies two years. They communicate and trade with the Hudson Bay natives, the latter sometimes visit Point Barrow, and some of them visited us at this camp. They differed in appearance from the Alaska natives; the tattooing, only seen on the women, being several parallel stripes across the cheeks. The women wore their hair in a knot on top of the head standing

about six inches high similar to that of the Eskimos of Greenland. They spent the day dancing and feasting. On hearing that I was out of flour they gave me a fifty-pound sack, which they packed several miles across the tundra.

June 25 to July 12. Remained at this camp waiting for the ice to break off from the coast. I offered every inducement to natives to take me to Point Barrow, but without success. One day a party arrived from the Point to trade. In the evening they got drunk on liquor they brought with them, and insisted upon coming into my tent, making all sorts of threats one moment and the next attempting to embrace us. The sober men of the party had taken their knives from them, and I was cautioned to keep my fire-arms out of sight. They stole everything they could put their hands on, the women returning them as fast as taken. The orgie lasted all night, and the next day they boasted of having been drunk and wanted more liquor. Considerable trading was done here, the interior natives exchanging all kinds of skins for rifles, cartridges, caps, lead and tobacco, which the coast natives had in abundance. Price and I had both suffered a great deal from constipation, and one evening a shaman gaudily attired, visited our tent in one of his trances. He appeared very weak though in reality the strongest man in the party, and remained about fifteen minutes rubbing his hands, shaking himself and whooping all the time. He then left, having cured us as he thought. July 12. Ten oomiaks started for Point Barrow. We followed, the edge of the ice being out of sight of land about an hour. Camped on beach. July 13, in camp, detained by ice. July 14. Underway, pushing through the ice. Dense fog set in part of the time and we were out of sight of land. The navigating of these people was wonderful. We made our way through leads, heading in every direction, and towards evening made the beach along which we tracked until 4 A. M. the next day, only six boats reaching this camp, the others being delayed by the ice and difficult navigation.

July 15, tracked along the coast, and at 9.30 P. M. made Point Barrow six miles above the old headquarters of the U. S. Signal Station, under Lieutenant Ray, U. S. Army. I made my way overland, and at 2 A. M., July 16, reached the house, ninety-six days from Fort Cosmos. Here I found Captain E. P. Herendeen in charge, and three traders, all stationed here by the Pacific

Steam Whaling Company for whaling and trading. I was very hospitably received and entertained. Everything they had was offered me, and pay offered, was laughed at. The ice was jammed on the northern coast and I was told it would be impossible to make my way along the coast to the southward as the ice floe extended as far seaward as the eye could reach. The northern shore of Alaska is very shallow and sandy. All along the coast great spits of sand are shoved up by the ice. The beach is filled with drift-wood. I noticed many timbers of wrecked ships though nothing that could be identified. Two small streams enter the Arctic between the mouth of the Ikpikpuk and Point Barrow.

August 11, I started with the Point Barrow party down the coast in skin boats to meet the whaling fleet to the southward if possible. Forty miles below the point we met the fleet making its way north through the leads, and boarded the "Narwhal," Captain Maillard. Learning that the U. S. Revenue Steamer Bear was just behind the fleet, I returned in the "Narwhal" to Point Barrow and awaited the arrival of the "Bear," which reached there the 12th.

August 13, embarked on the "Bear," Captain M. A. Healy, U. S. R. M., commanding, for transportation to Hotham inlet. August 25, reached Hotham inlet and reported my return to the commanding officer.

XI.—Animals, Birds, Etc.

The mosquitoes are the first things noticed on arrival in the country. Nowhere have I ever seen so many as on the Putnam river during the summer months. It surpasses imagination. We suffered more from this pest than from anything else. At times they would drive us to distraction. The dogs would rub off all the hair around their eyes in efforts to drive the vicious things away. The poor animals would dig holes and crawl in them, hauling the dirt down over them, in their efforts to get rest. Smoke was the only thing of any avail against them, so the first thing on stopping was to build a fire, when the dogs would actually shove their heads right into it to keep the pests off. It is during a calm that the mosquitoes are so bad. The least wind drives them away. The natives relate instances when the mosquitoes have caused the death of reindeer. These animals gen-

erally keep off the low tundra land, when these pests are worst. But the deer occasionally during a light breeze venture into these bad places. The wind dying out the mosquitoes rise like a cloud and attack them, especially around the eyes. They run frantically for high land; but the mosquitoes get in their eyes and actually obscure their sight. In a short while the eye swells and the animal loses his way and wanders around. Eventually they succumb and die.

I provided my party with an arrangement that gave them full protection. It was a hood of light drilling which came down over the head and shoulders, with holes for the arms, by which it was readily held on. A steel band ran around the face of the hood and on this fitted a movable mask of fine meshed copper wire. In the lower part of this mask a hole was made with a hinged cover of the same material, so that a man could smoke or eat without removing his mask. When there is the least wind the mosquitoes do not bother one and the mask can be removed and hung to one side as with a soldier's cap. The mask was made of wire gauze because the mosquito netting tears so easily. Having to use instruments in observations for latitude and longitude, I made an additional hole in my mask opposite the eye used.

Bears were very numerous and the natives were abundantly supplied with their skins. We saw four kinds, black, brown, cinnamon and a small bear of gray color. They never gave us any trouble, though we saw natives who had been in encounters with them.

Black wolves are also quite plentiful, and I saw a number of blue wolf skins. We saw four kinds of foxes, red, silver-grey, white, and a cross-fox. Other animals were numerous, such as the wolverine, land otter, marten, mink, beaver, muskrat, and ermine, wood rats, squirrels and white rabbits. Porcupines were everywhere and in great numbers. The only animals of the deer family in the country are the caribou, which are killed by the natives in great numbers.

Waterfowl of all kinds are plentiful during the summer, but migrate south on the approach of winter, except one small variety, something like a sand piper, which remains during the whole year, as do the blue-jays, crow, ptarmigan, white owl and grouse.

Fish.

There are many varieties of fish in the rivers and lakes. Most of which are mentioned elsewhere—but the salmon is the principal one. There are three varieties of this fish in the Putnam and its branches on the north side of the river, but strange to say, not one is to be found in the streams coming in from the south. The reason of this I do not know.

Specimens of every variety of animal, bird, fish, and insect life, besides woods, mosses, and minerals, were collected during our stay in the country which were forwarded on my return to the Smithsonian Institute.

Geology, Etc.

The geological formations of the Putnam river valley show much disturbance and change, as may be gathered from the description given in other parts of the book. Granite rocks are the most abundant, though there is much limestone, slate and conglomerate in the upper part of the valley.

Gold Prospects.

Looking for gold was not one of the objects of my expeditions to the Putnam river country and no effort was made to find it. On our several exploring trips, the ground was always covered with snow, and the weather intensely cold, and in the summer we were engaged in other work, surveying, etc., and had no time to give to prospecting.

On my second trip, however, I was joined on the river by an old miner named Miller, who had come in with a party from the revenue cutter. They turned back after going a short distance up and Miller asked to join my party. I took him along to chop wood for the steam launch. Whenever we stopped Miller would go with a shovel and wash the sand on the bars of the creeks emptying into the Putnam, looking for gold. He invariably found traces of the precious metal, more in some places than in others, and would show me the "color," as he called it, which consisted of specks of fine gold.

Miller said at the time that the prospects here showed better than on the Yukon where he had been prospecting for a year. He was very enthusiastic about it and begged me to "stake"

him with grub so that he could remain in the country and continue prospecting; but I could not comply with his request, as I had none but Government stores with me, and these I could not dispose of in such a way.

Coal.

On my second trip to the Putnam I discovered a vein of bituminous coal outcropping on the north side of the river about ninety miles from the mouth. I tried a lot of it in the furnace of the steam launch with very satisfactory results, though it had been long exposed to the weather. The vein was between two and three feet thick and dipped at an angle of 30° from the river. I think that a good quality of coal will be found further in the bank.*

Trees.

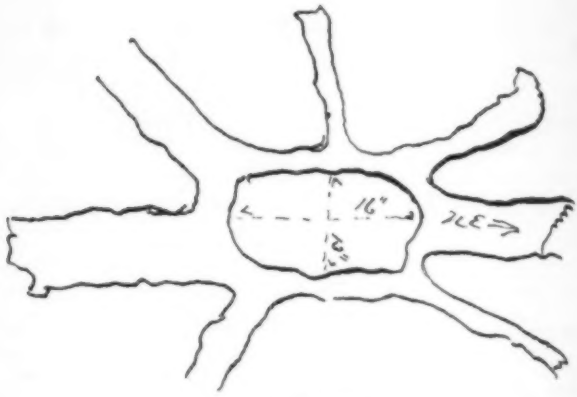
Fair specimens of the various kinds of trees were cut down, measured and inquiries made of the natives concerning them; the following notes thereon are submitted.

Spruce.

A spruce tree cut near Fort Cosmos was a good example of its kind. Height, 50 feet; N. E. diameter of trunk, the longest, 16 inches; N. W. diameter, the shortest, 13 inches. Branches began three feet from the ground, increasing in size and length to the middle of the tree, then diminishing to the top. The branches next the ground were dead, as is always the case. Branches from three to five feet long never have a greater diameter than 2½ inches. This tree inclined to the southwest (as most of them do). The roots to the northeast were longest and largest, one being nine feet long and eight inches in diameter. The depth of soil in which this tree grew was but seven inches, the smallest threads of roots went no further down. The main root extended five inches below ground. All the roots ran laterally in soil of black and gray dirt with light sand and dirt below. All the spruce trees were about like the one described. In the Putnam valley the roots are longest and stoutest to the north-

*For an account of the curious mineral substance found by Ensign Howard, see account of his trip to Point Barrow.

east; in other valleys this applies in the direction of the prevailing winds. All side roots are small and unimportant. The little soil over the roots is barely sufficient to hold the trees against the prevailing winds of summer. The snow and freezing of winter enable them to stand the gales of that season.



TREE ROOT.

The native name for spruce is Nu-puck-tuck. The trees lose their leaves in spring; they get frozen to the tree in winter and so cannot fall. When young and tender the leaves are sometimes eaten as food.

The Cotton-wood.

The cotton-wood grows all over the country and is found in places where no other trees grow. The wood splits easily and on this account is often used in building, and in making fish-traps. When spruce or birch is scarce it is used for canoes. It is also used to weaken too strong tobacco, and to make it last longer. The cotton-wood dies first at the top, caused by the winds cracking the upper bark which lets in the cold. The native name of the tree is Nimyuk, hence so many villages of that name.

Birch.

The birch are clean, well-shaped trees, varying in height from twenty-five to forty feet. A specimen tree cut was 31 feet high;

circumference at butt, 18 inches; five feet up, 16 inches; at ten feet from butt, 13 inches. Branches began fourteen feet up, none lower, and not very many above. The largest trees all seemed dead and on them a parasite was found. Before dying, when the branches show signs of decay, a soft white fungus appears; after death this changes its color to slate or gray and becomes hard. The birch grows all through the country and is not confined to the water courses like most of the other trees.

This tree shows the advancement of the seasons; its buds are the first to appear in the spring and its leaves are the first to change color in the fall. The tender wood of the branches is eaten with the juice of the tree. The native name is Ool-la-le-yuk. Its wood is the hardest of all trees and is used to make sleds, bows, etc. The bark is gotten in spring and from it are made canoes, house coverings, pans, etc. The buds are eaten by ptarmigan. The fungus called ap-pa-chuck women mix with their chewing tobacco.

The Willow.

There are several varieties of this tree. The specimen cut at Fort Cosmos will serve in dimensions for all. Its length was 17 feet; circumference at base, 6¾ inches; five feet up, 5¼ inches; ten feet up, 4 inches. About five feet up the branches begin increasing and so to the top where they are thickest. The largest trees are 10 inches in circumference at base, but these usually had dead tops and from the lower parts numerous sprouts grew. The willow growth is mostly thick like that of the Mexican mango; it is more of a shrub than a tree; it is found on all the lakes, and along the banks of the streams its growth is rank.

The native name of the above specimen is Con-nugn-yuk, and it is found in all parts of the country. It is sometimes used for bows when birch is scarce, and snow-shoes are made from it. The ptarmigan eat the buds, and the moose and bears, the twigs.

Another kind of willow is the Oak-pik, similar to the above in most respects. The bark is used to make nets. The animals eat the buds and twigs as above. A third kind is Ar-koo-too-ark. It has a fibrous blossom from which match-rope is made. The buds of the young plant are eaten in summer. Animals eat them as in the other kinds. This willow grows around lakes and rivers and in the water. A fourth species is Nu-wung-yuk. Its

bark is used as a red dye, made by scraping it fine and letting it stand in water until it turns red, when it is mixed with the water. From the wood, pipes, snow goggles, etc., are made. Ptarmigan and rabbits eat the buds, beavers the roots, and moose the twigs. This willow never grows in water; it thrives on high land and on elevated tundra.

Fuel Wood.

Dry spruce wood was used exclusively in the boats for fuel; other dead wood gave poor results. The standing dead spruce was used; the higher the land the better the wood, having fewer knots and a straighter grain; in the low wet places the grain of the wood runs spirally. The green spruce gave no satisfaction in the boats but did well in the heating stoves at Fort Cosmos and was used altogether. In the summer the green spruce is nearly impossible to split, owing to the sap; this in the winter freezes and the wood is split with ease. The opposite is the case with dried spruce.

The largest tree seen in the whole country was a spruce near the headwaters of the Putnam. Dimensions, circumference at base, 80 inches; six feet up, 68 inches; height, 80 feet. Trees of this size, however, were seldom met with.

XII.—Natives.

The people inhabiting northern Alaska are known by the general name of Inuits and belong to the Esquimau family. They seem to be divided into geographical sections each having its own name; thus, those about Point Barrow are known as the Ugliammis, those about the Peol river are the Tatlits, those to the southward on the Yukon are the Kutch-a-kutchus. Those with whom I was most thrown along the Putnam, Selawik, Notoark and Colville valleys are known as Malemutes. It would be difficult for me to say much concerning their origin. Long ago they were undoubtedly closely allied to the natives of the Koyukuk river; because the oldest natives of the Putnam valley still speak that language and say that their fathers knew no other. But further than this I could learn nothing.

The Malemutes all speak the same language and have the same customs and social laws. Those living in the Putnam or Kubuck valley are called Ku-wung-mutes; in the Selawik valley, Se-lew-

ing-mutes; in the Notoark, Notoarkmutes; and in the Colville or Kunyanook they are Kunyamutes. Their complexion is light brown, the color of a new saddle. The skin of the face is darker as it is much exposed and seldom washed. There are shades of color but such diversities are merely accidental. The features are quite regular; the countenance round, and the expression open and good-natured. The eyes are small and black and nearly even with the face; the eyebrows short and straight. The nose is small and flat; the mouth, large with moderate lips and good teeth which in the old get worn to the gum from hard use. The hair is black, long, coarse and straight. Aged persons become gray but seldom bald. In stature, weight and size they compare favorably with the whites. The shape and size of their heads are normal and well proportioned; the forehead is high, like Europeans, the cheek bones are slightly prominent, but less so than in the North American Indians.

The faculties of seeing and hearing are highly developed, but the senses of smell and taste seem to be deficient. In actual masculine strength they are inferior to the whites, nevertheless their power of endurance is remarkable; they travel unceasingly and untiringly, regardless of the severity of the weather, and oftentimes with insufficient food and little sleep. Concerning their longevity it is difficult to say; there are many old people especially men, numbers of whom are grand-parents but they are very decrepit. The age of puberty is the same as in whites. There is nothing peculiar or strange connected with the functions of generation; they are subject to the same laws as the other races of human beings.

The women braid their hair in two long plaits hanging down the back; occasionally a man does the same. The men, however, as a rule wear the hair long and flowing excepting a bang across the forehead. They are generally beardless. It is said that they pluck out the hair, only permitting it to grow when they become old men. Tattooing is restricted to the women. It consists of a few lines on the lower lip and chin, and is seldom done until after marriage. The cartilage of the nose in both men and women is often pierced, though no rings or other nasal ornaments were seen. Ear-rings are worn by all the women and some of the men; bead ornaments on the hair and bracelets, only by the women.

Wearing labrets in the under lip just below the corners of the mouth, is confined to the men. The custom seems to be dying out, for though all the old men had pierced lips many of the young did not; also many who had holes for them wore only a single labret, and others, none at all. The first eventful ceremony in the life of a youth is the operation of cutting the lower lip for the labrets; after it he assumes the prerogatives of a man. The holes are cut by some old man, generally a medicine man, with a knife. The boy stands the operation uncomplainingly, pushing his tongue against the inside of the lip so as to assist the doctor. Before the cutting, the boy has to make presents to all the old people in the village, and in return he receives their blessings. If he be the son of a wealthy man he gives skins, knives, etc., but if poor he gathers and distributes large quantities of berries and roots.

Marriage.—The marriage ceremony is an unimportant one and seldom attended by any demonstrations. A man desiring a woman for his wife obtains the permission of her parents, and then asks the woman. Should either object there is no marriage. If accepted he makes presents of clothing generally to the parents, sometimes to the bride. If the groom be rich his marriage is sometimes followed by a supper and a dance. The public announcement of marriage is by word of mouth. The wedding is of the simplest, the groom goes to the hut of the bride and establishes himself there or else he takes her to his to-pee.

Polygamy though lawful and practised is not general, the limit to the number of wives being the ability to support them. The wives live in the same hut if they can do so amicably, but when this is impossible the favorite wife is retained and the others cast out to shift for themselves. Widowers re-marry. In case of disagreement between stepmother and stepchildren the stepmother leaves, and another and more acceptable wife is taken. Widows also re-marry, but their children are distributed among the deceased husband's relatives, so that on their second marriage they are unencumbered. Relatives marry, but incest is not approved and seldom committed.

Death.—Death is regarded as a necessity and the natural end of man. Their grief is violent for a couple of days, occupied by loud crying and moaning, and then it passes. The ceremony of burial is simple; the most common way, that practised by the

Notoark natives and to a limited extent by all the others, is to place the corpse on the tundra and leave it to rot or become the food of beast or bird. The Putnam and Selawik tribes sometimes put the body in a rough box of hewn logs placed on the tundra. Frequently the dead are placed on the ground and a tent of poles made over them; and again they are laid between and across uprights.

The graves of the rich are distinguished by stones or poles piled about them. The dead are never placed underground. Sleds, arrows, utensils, tools, etc., are left with them, but no food. It is believed the dead go south, returning often as ghosts, and sometimes they can be seen playing games in the aurora. Graves are always visited soon after the interment to ascertain whether the dead have returned to life; but these visits are not often repeated, and the departed are soon forgotten except in story and legend.

The men live the longest. Judging from the great number of graves seen, and the reports of the natives, the race is diminishing, and the death rate largely exceeds the birth rate. The summer is the season of illness, and in the fall they die. Pulmonary diseases are the most prevalent, the damp and exposure of summer give bad colds which, for lack of treatment, develop into something more serious. A few get frozen to death.

Characteristics.—It can be stated that these people of northern Alaska are of exceptional good temper and kind disposition. They are tender and considerate to the aged, and possess a wonderful love for their own blood. The friendship between Ounalena and Callupuck was closer and more devoted than is often met with in more civilized places. Ounalena had been my guide on my previous trips and had died during my absence; his brother Callupuck was my guide on my last trip. Callupuck cried when he first met me, telling the story of Ounalena's freezing to death in the cold of last winter. Great tears rolled down his unwashed cheeks as he spoke of his brother's bravery, his power, his hunting, and his love; and when I showed him the old chart his brother had made for me, he broke out in sobs, "Oh yes, I loved Ounalena better than my wife; I could get another wife, but never, never, another brother."

Relationship is binding; the most distant cousinship is recognized. The family never forgets its own no matter how far they

may be separated. Parents are noticeably kind to their children. They work for them, help them, and do everything to please them. The male children are preferred; a father will exhibit his boy with the greatest pride but the daughter will be kept in the background and merely mentioned, yet each is treated with equal consideration in their bringing up. The young babies are in the care of their mothers, who carry them inside their parkies, usually on the back so as not to be in the way when working. The older children are carried astride the necks of the women with their feet held in front to prevent falling. The excessive pigeon-toe formation of the women's feet is probably the result of this mode of carrying, for the girls are kept on their mothers' necks longer than the boys.

A sort of communism exists among the natives in a village; all articles are used in common, and borrowing and lending are obligatory and customary. The aged and infirm are taken care of by the people of the villages in which they live; so are the sick and helpless. Blind people are looked out for by their friends. Insane people, of whom there are a few are in charge of medicine men, who bleed them to effect a cure. Violent lunatics are killed. They have no chiefs, but a decided respect is paid the richest man, and his voice is the deciding one. They are very imitative and practical and follow the whites as much as possible, adopting such habits and customs as will be beneficial to them.

The women have entire control of the food, regulating when it shall be eaten, the kind, and the amount. They are always consulted in all matters relating to trade, traveling and domestic affairs. Though apparently treated with indifference their influence is distinctly felt. Instances are numerous where a man's stout denial has been changed to ready assent after an interview with his wife.

Crime.—The only disturbing element in the lives of these simple people is WOMAN. For her they quarrel and fight and even commit murder. A murderer is invariably killed by the son of the murdered man, if there be one, or by the brother or father. It may be that the proper avenger is too young to appreciate his responsibility as avenger, if so the matter rests until he reaches a proper age, and he then does his duty to his murdered parent by taking the life of the son of the murderer, for the original criminal will doubtless be too near the grave to make the killing him a satisfactory reparation.

Stealing is the greatest moral offense. A thief is looked down upon by everybody, and is treated with the greatest contempt. I knew of a case where a husband left his wife because she stole; he took his son with him, but said he had little love for the boy as he was the child of a thief. During my whole stay amongst these people I never heard of a case of theft.

Suicide is rare. There are instances where incompatibility has made life unbearable and the man hanged himself. So too, great sufferers get their sons or wives to end their miseries by sticking a knife or spear into their hearts.

Social Customs.

Heirships.—A son generally lives with his father until the old man dies, when he marries. Should there be several sons the older ones marry and establish their homes leaving the youngest to take care of the father. In case of death the property goes to the eldest son who divides a small portion of it among his brothers and sisters. The mother gets no property but is domiciled with the heir and exercises great influence in all his bargains. If the eldest brother dies childless, the next brother succeeds to the estate. Daughters are not lawful heirs but their uncles must give them a little something. When there are no sons or brothers the succession goes to a sister of the deceased. A child heir has his property taken charge of by his uncle who also must take care of the widow until the son comes of age and assumes the responsibility.

Surgery.—Surgery is practised in the cutting off of frozen limbs. An assistant holds the patient and the medicine man performs the operation, cutting off the frozen part. The limb must mortify before cutting so that all the tissues will be contracted; no live flesh is ever cut. The instruments used are a knife and a saw and nothing is placed over the cut except a little seal oil. The invalid must stand the pain without flinching or uttering a sound. An ordinary severe cut is sewed with sinew; a serious cut is bandaged tight above the place, and then sewed. The loss of a finger is healed by sewing flaps of skin together over the bone. All these operations are performed by doctors or medicine men.

Medicine.—The only medicine employed is seal oil; its action is laxative. To cure ordinary petty illness such as headache,

rheumatism, etc., the patient lies down and a belt from round the waist of a medicine man is put round the head, arm or leg as the case may be. Through the bight of the belt a stick is run as a lever. The shaman then asks questions of the spirits and raises on the lever; if the answer concerning the patient be favorable the member in the belt comes up easily; if not, in spite of all his pretended straining and groaning, the sick member will not move, as he makes it appear. Some natives before traveling go through this nonsense to ascertain whether they will remain healthy during the journey.

Doctors.—The influence of a doctor is all-powerful; he heals the mind as well as the body; he has much to do with the success in hunting and fishing; his tenets are those by which the people live. There is absolutely no knowledge or idea of a god or of a providence; nor is there worship of any kind, of animal, idol or things. A doctor, medicine man, or shaman is born, not made. The superstitions surrounding the "Unatcoke" (doctor) are unique. The child is born with blood over his eyes, and at four years of age blood comes from his eyes and his forehead, which must be wiped off by his mother or brother. No especial attention is given his babyhood. After his fifth birthday the child goes into the mountains, remaining from one to five months. In this retreat he sees the ghosts and holds communion with them. They instruct him, taking care of him, and feed him on back fat of deer, bushes, berries, etc., returning to his home the young doctor, in the presence of friends, vomits all he has eaten during his seclusion. He is now prepared for the many functions of his sacred office, and is qualified to cure his relatives of diseases. His position in the community is advanced; he takes what he wants, and can refuse meat if he by his occult powers, sees it is in motion, for to eat would cause his death. His trips to the mountains are made frequently and oftentimes in company with other associates. With increase of years comes increase of knowledge and power; he ties himself apparently hard and fast, and then suddenly gets loose, and performs many other simple feats of legerdemain; he spits fire; he pulls birds from his mouth; and he does tricks of jugglery. It is commonly believed he can cure all ills; that he can drive away by his spells the fish and deer, and perform miracles, even raising the dead to life. Whiskey he makes from water, and back fat from snow.

A doctor occasionally fasts for four days, and in order to renew or refresh his powers, holds communication with ghosts introduced by some other all-powerful shaman. By consulting the white man's ghosts he procures tobacco and gets beads. In the ordinary affairs of everyday life he does his share, nor is any great deference paid him, except when in the performance of the duties of his sacred office. He dies and is buried like other men. However, his spirit returns, and visits the earth four times before taking its final departure. There is a story that an Inuit doctor was beheaded and his body was placed in a dance house while his head was thrown into the sea; in the morning the head returned to the body and the man became whole.

Doctors marry, their wives living in the villages; they also have ghost wives in the mountains. Their offspring sometimes become doctors, but not of necessity. Women likewise are doctors possessing all the occult powers of the male members of the order. They marry. Sometimes they become the wives of the ghosts in the mountains as well as of men in the communities.

Perfect faith in these medicine men is not held by all. There are different degrees of confidence; and a few are prophets without honor.

Amusements.—The outdoor sports of the natives are very like those of the whites. The boys play shinney and are sometimes joined by the men. And they jump, wrestle and kick. In all, the old men take the deepest interest, encouraging and directing the youths. Kicking at a suspended object is great sport and amuses them for hours. Observing that some of them could kick higher than their heads, I had the object raised as high as I could reach and offered a prize of a sheath knife to the one who could kick the object. The young men tried repeatedly and failed. Finally an elderly man who had been directing the others was induced to try. Taking off his clothes, he made the attempt and succeeded. My men could not kick as high as the natives, but could beat them at jumping.

Tossing in a blanket of sealskin is a favorite pastime. The person tossed—man, woman, or child—goes through the motion of walking while in the air, and must alight on his feet in the same way. When he falls he is laughed at and some one else takes his place. Those holding the blanket sing and shout; as many as fifty people, men and women, sometimes enjoy this sport.

Dancing is the greatest pleasure of men, women and children. It is of different kinds, representing animals, birds, hunting and fishing, the habits of the whites, etc., and is always accompanied by all manner of contortions, persisted in until the participants are prostrated by sheer exhaustion. A good dancer is a man entitled to consideration and respect. As much noise and fuss as possible are made at these dances; tomtoms are beaten, and all hands sing and shout a rude monotone with their greatest power.

Card playing takes precedence of all games. These people are natural gamblers, and never let an opportunity pass of gratifying their passion. The game is Russian, played with a pack of ordinary playing cards, bought for a high price from the traders. They call it Car-tuk, playing it continuously sometimes for forty-eight hours. So infatuated are they with it, that even the few moments of rest on sledging trips are passed in gambling. The stakes are sometimes high; a man often loses his entire stock of skins at a sitting. Women play quite as well as men, but their stakes are never high. This habit of gambling with cards is becoming common to all the natives, even to those who have never seen a white man, yet it was introduced into the country but four years back. So prevalent is it that already there are some professional gamblers who live principally by their winnings. One of these came to my camp and lost everything. However, he got me a raft of good logs, and with his payment again tried his fortune; and when he left he had a good stock of skins. The game of poker is understood by a few and in a year or so will probably be very popular.

Music.—The natives are exceptionally fond of vocal music though their songs are decidedly monotonous and, to my ears, destitute of melody. Whenever a native from a different locality comes among them and sings a new song they gather about, listening until they catch the tune, when they take it up and sing it for hours. The tomtom is the only musical instrument.

Traveling.—When the river breaks traveling begins, some go to the mountains, and others to the coast. Those going to the coast carry their families and all their possessions in large skin boats (oomiaks) the owner steering and the others paddling enough to keep in the stream while the current takes the boat down. Two or three small families often go in one large boat. They follow a day or so behind the ice, reaching Hotham inlet be-

for it gets clear. Stops are made on the journey to catch fish for immediate use and for use at the trading station. A rich man travels in state; he never takes any other family than his own; he hires paddlers and a steersman; and enjoys all the luxuries he can. In returning up the river, they track along the banks using dogs. A sealskin tow line twenty to thirty fathoms long is made fast to a knee one-quarter the length of the boat from the bow, and four to six dogs are harnessed to the other end. A boy goes ahead as a dog leader and a man follows as driver; the latter's position is not an easy one; sometimes a dog will go to one side of a bush and the next dog the other side, or the head dogs will go over a fallen tree and the others under it, causing trouble and a dog fight and necessitating a delay to straighten out again. About two miles an hour is made in tracking; delay is caused by the dogs having to be shifted often from one bank to the other in order to get good footing. Occasionally in places dogs cannot be used and recourse is had to poles and paddles. Whenever the wind is fair sail is made. Lazy natives often wait two or three days for a wind rather than pole or paddle. Should a boat be under way all night as sometimes happens, the occupants stand regular watch.

On the return trips they fish a great deal, loading the boats down with the catches. Whenever stops are made boats are discharged, hauled up and turned bottom up to dry; tents are pitched, and camp made. In times of great hurry tents are not pitched, shelter being found under the lee of the boats. The families of the hunters remain in tents on the watercourses and catch and dry fish. At the first indication of thawing the winter huts are deserted and deerskin and drilling tents resorted to.

Hunting and Fishing.

Hunting.—Deer hunting is the most indulged in. The most successful hunter is the hero of the season, hence the sport is eagerly pursued and greatly enjoyed. Many superstitions surround the deer; at times the meat must not be cut with an axe, nor can it be cooked in the living house; only certain parts should be eaten, etc. All these observations are particularly necessary in the case of white men; and are rigorously enforced unless they are given a valuable present. There are deer all through the country, especially in the mountains at the headwaters of the Put-

nam, Notoark, Allashook and Colville rivers, where they gather in large herds, and numbers are caught by the following ingenious plan.

Running for miles in two converging lines they make piles of stones four feet high and having the general resemblance of a man. Beginning at the outer ends of these lines, which are miles apart, the piles are built every thirty yards; the distance gradually lessening as the lines converge, until at their inner ends, where the width is about forty yards, the piles occur every ten feet. Connected with the inner ends of these piles is a circular place marked out by bushes concealing a rope securely fastened at the ends and in other places along it. To this rope are made fast numerous laniards having slip nooses at their ends open and held up properly in the bushes by small stakes. The deer are driven inside the lines without observing the stones; the natives then close in shouting and frightening the deer, who mistaking the stones for men rush on and seeing the opening ahead dash at the brush and are caught in the nooses by the horns or legs when they are killed by spears. As many as twenty-five are caught at a time.

In the narrow mountain passes frequented by deer similar arrangements are made. One native caught ninety deer during the season. In the big lake near the limit of the mountains large herds of deer gather in the fall. It is shut in by the mountains, with the ends open and accessible, but the sides so very steep that only in places can the deer climb; at such points some natives conceal themselves while others drive the deer in the ends. The hidden natives rise and make a great noise and the deer becoming frightened take to the water, where they are speared from light canoes made of deer skins shaped like the kyaks of the coast. Hundreds are killed in this way. When I reached the lake early in March I saw a great many dead deer lying about the banks untouched. These deer are killed in the fall when the herds begin gathering to move further south and at this season they are in best order and the back fat is gotten.

Bears.—Bears are numerous but are very shy and not often encountered, though their tracks are seen in all parts of the country. Some localities are recognized as their homes, notably the small tributaries of the Putnam near the headwaters. The

natives say that in winter the bears live on high land in dens carefully constructed of leaves and lined with reindeer moss, each den having three to ten bears. These places are discovered in winter by observing the bear marks, such as broken bushes, nail prints on trees, earth thrown up on adjacent brush, etc. Finding these, the snow is cleared away until the tracks leading to the lair become distinct, which is then surrounded by several natives and the bears killed by spears.

They are also killed by shooting them from blinds made of brush set up on the banks of the rivers at the places where the animals come down in early morning and late evening to get the fish swimming in shallow water. The natives say that the bear has one young one the first winter and thereafterwards two. The period of gestation is from ten to eleven moons and birth is in the spring just before leaving the winter dens. During the long winter they live by sucking their paws. The natives say that they eat clay which they retain until spring.

The preparation of the dead bear for eating is a superstitious proceeding. The skin is removed from the head and the head cut off. A native then takes it and standing astride the body with the head in both hands raises it high in the air and lowers it three times, touching the body each time just over the heart and muttering an incantation. After the third touch he throws the head with all his might so as tc hit the same spot over the heart and utters a loud shout in which all the natives join. This ceremony is supposed to drive the bear's spirit to the mountains. After removing the skin the abdomen is opened with more superstitious observations; but never in the presence of a white man; and certain parts of the animal are left on the ground, for to remove them would drive the deer from the mountains. The ears are always cut off the skin.

Mountain sheep are killed with rifles. These sheep are not numerous; they live in the mountains and are very wild. Their white skins make good blankets. The other animals are also shot. But they are principally caught in traps, the old-fashioned figure 4 under a heavy log, and the common steel trap being used.

Ducks, geese, ptarmigan and other birds are shot and caught in nets and traps, especially the ptarmigan. In the spring when these birds are mating, they are very combative, and the males fight one another constantly. Several birds are shot, skinned,

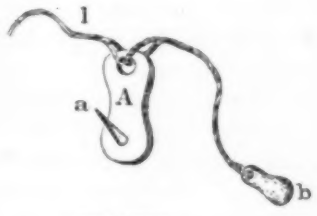
stuffed and made fast to a net twenty-five feet to forty feet long and three feet deep, made of sinew quite like a seine but with smaller meshes, set up on the rocks and bushes where the ptarmigan feed. The live birds attack the decoys, get enmeshed, and by their struggles attract others who likewise get caught. By this means great numbers are captured. Another way of getting ptarmigans is to set small nooses in the bushes near the ground, the birds get their heads in and draw the cord tight in their efforts to escape.

Waterfowl are caught by anchoring to the bottom of ponds a piece of whalebone to which is attached a number of small nooses. The birds in diving for food get caught by their heads. During the moulting time in spring, birds, particularly geese and ducks, lose most of their wing and tail feathers and being unable to fly are speared.

Caching.—There are three ways of caching; above the ground, on the ground, and under the ground. In the former way a scaffold eight or ten feet high is built, and the meat placed on top covered over with a deer skin. Underneath the scaffold is hung by a piece of sinew, some small bit of clothing that can be moved by the motion of the wind to frighten away wolves and foxes. In caching on the ground, resorted to when wood is not convenient, the deer is placed so as to have the feet sticking up through the snow, and attaching to one end of the legs a small fluttering object which keeps off the enemy. The third way is described elsewhere, in the account of my sledging trip to the Notoark. I often noticed wolf tracks all around the caches but never dangerously close. It is thought that they fancy a trap is set for them, and so keep at a safe distance. A cache is regarded as sacred. Only to save life is one ever opened, and in this case the owners are found and paid for what is taken. All hunting parties cache their meat, leaving it until it is needed. So do traveling parties who go so heavily loaded that they can carry but little food.

Fishing.—All means are used to procure fish. They are caught in seines, by spearing, with hook and line, in traps and in gill nets. Seines are made of the under bark of the willow plant and from grass; stones and pieces of antlers make the sinkers, and pieces of spruce wood, the floats; the whole when completed is about seventy-five feet long and four feet deep and is like the

seine of commerce. Women and children always haul the seine, running it from a woman's canoe—a small boat of birch bark—very much as white men do. Often a thousand pounds of salmon are taken in a haul. The salmon start up the river soon after the ice leaves and run until it freezes. As soon as the fish are caught they are split open down the back and the back bone removed; they are next spread out on poles until perfectly dry when they are put under shelter and lightly smoked for several days. The object of smoking is to prevent the fish getting fly-blown. Spearing fish is the amusement of the boys and men. It is done from the banks and in kyaks. In hook and line fishing the lines are made of whalebone strips and the hooks of ivory with sharp metal points. The figure gives the idea; "b" is the sinker of ivory. "A" the ivory part of the hook into which the metal point "a" is fastened; and "1" is the line. No bait is used, the hook arrangement corresponding to the fly. Fish baskets made of willow and like those in ordinary use with us, are common in these waters.



FISH HOOK.

When the river is frozen, fish are caught by digging a trench in the ice and placing a row of stakes in it close together and reaching to the bottom; this picket as it were, is allowed to freeze in the trench. At one end a pen is made connecting with the fence by a funnel-shaped basket, the smaller end opening into the pen. Fish follow the fence and entering the pen through the basket cannot get out. A hole is made in the ice over the pen, and the fish speared and brought out. In the early winter a great many are caught in this way; but none as the season advances. Hooks and lines are used principally through holes in the ice when the river first freezes.

Nearly all the lakes as well as the rivers abound in fish, al-

though in some the water is too deep for much success in fishing. This is especially true of the large lake drained by the Colville. Its fish are Su-luk-pow-wuk, Copetic, Col-lic-pic, and Col-lick-puck the largest of all these fish. Natives have a story that they are sometimes over fifty feet long and swallow a deer, horns and all.

Salmon.—Salmon of several varieties are found in the Putnam river. They are at their best in Hotham inlet before starting up the rivers; then they are fatter, their meat is firmer and of a deep red color, and their shape is regular. Those caught up the river late in the fall would hardly be recognized as the same fish, their backs were bowed and had spots on them that were soft and seemed to be decayed meat. A great many dead ones were seen up the river. According to the natives, those fish that go up never come back, and after spawning, unless they are caught, all die. The cause of death is said to be starvation, as they never eat in the river. In many that I examined, I noticed that there were no visible traces of food. The young fish are supposed to remain in the river until the ice breaks when they go to sea, returning after an absence of three years.

Food.—The principal food of the Selawik and Putnam natives is fish; it is the most relished and is preferred to any other meat and is eaten either cooked or raw. Besides fish, all animals and birds go to supply food; especially the deer. With the other natives, deer meat formed the principal food. Every part of the deer has its uses. The skin furnishes material for huts, tents, boats, clothing, bedding and rope; the sinew, thread; the antlers, sinkers, tool handles, etc.; the hoofs, as small boxes; the hair, mixed with tobacco, is smoked; the bones, crushed and boiled, yield oil; the marrow gives grease and hair oil; from the contents of the stomach a soup is made and the flesh is eaten raw or roasted or boiled.

As soon as a deer is killed the throat is cut and he is skinned and the back fat cut off. This is the most highly prized part of the animal and is the favorite dish at a feast. It is eaten raw, boiled and roasted. To me it tasted like rank fat bacon. The cooked meat is either boiled in pots or roasted on wooden spits before the fire. I thought it excellent, also the marrow from the hot bones. The raw meat frozen is eaten on the march; I found it good. Generally when there is a surfeit of deer, the lean meat

is given to the dogs, the natives preferring the fatter portions, intestines, and those parts usually thrown away by civilized men. The bones are cracked and the marrow extracted. The joints are saved until a sufficient quantity having been accumulated, they are pulverized by pounding between two rocks and then boiled; the grease is skimmed off and allowed to cool when it looks like lard. It is considered a great delicacy.

In the spring the backs of the deer are covered with parasites that spoil the skin by eating holes in them. They are an inch long, one-fourth of an inch in diameter, tapering at both ends, and cream colored. The natives say that they eventually turn to butterflies. These parasites are eaten raw and considered a delicacy. My disgust when offered them was regarded as ridiculous. Bear meat cooked like the deer is highly prized, and especially the paws.

The smaller animals, mink, marten, etc., are skinned, skewered and stuck up opposite a good fire to roast. Their meat was not bad. Birds, after removing their feathers, are spitted and roasted like the animals. They were very palatable. Seal oil is the condiment used with all food. It is eaten with the fingers, and each finger dip is followed by several mouthfuls of food.

Nothing is cultivated for food, so recourse is had to the natural productions of the soil, principally roots, buds and berries, eaten raw and prepared in different ways. Most of the roots are stringy, and are boiled before eating, though for want of time and fuel they are sometimes eaten raw.

Among the most common roots used for food are: the mashoo, tasting like the sweet potato, eaten raw and boiled; the arcot, like the mashoo, but of different smell and less liked, prepared the same way; ka-ka or pick-neck, a grass root around lakes and in damp places, boiled; karga-neck, a small ground root, boiled; koat-le-ruck, a plant, leaves and stems, boiled; ar-ku-toak-puck, a mountain plant, roots eaten raw; ko-ong-oo-lick, a plant put up in oil, kept for winter, eaten raw; ish-u-a-muck, kept for winter, eaten boiled; pil-lun-wick, a plant found around lakes, only the roots eaten, raw or boiled; mis-suck, the young willow, the buds are mixed with oil, eaten raw summer and winter; oueyelalook-missun, the juice of the birch drunk as it comes from the tree; narkoowick, a sea-weed, boiled and eaten with oil—to eat this raw would make one cross-eyed, hence its name.

The berries, of which great quantities are gathered, are put away for winter use. They are sometimes preserved in either seal or deer oil according to which is on hand. The deer oil is easily obtained in the mountains, the seal oil on the coast. Seal oil they prefer, though to my taste there was but little difference. The berries used are: arc-pu, the salmon berry, eaten raw and in oil; as-se-yer-wick, the whortleberry, eaten raw and with oil; oak-py-ge-wick, the currant berries; ig-ge-wing-wick, rose berries, seed and all eaten; kip-my-ye-wick, small red berries growing on low bushes, boiled and eaten with oil; tar-ted-e-nim-as-se-ark, small red berries, put up and eaten with or without oil; too-look-come-as-se-ark, kind of whortleberries growing on large trees occasionally eaten with or without oil; pow-ner-ark, a small berry growing close to the ground, eaten raw or with oil; cub-lack, black berry, eaten raw or with oil; aug-ook-wick, a red berry eaten raw and with oil. Berries are eaten before the regular meal and constitute a course. Natives have lived on them exclusively for five days, but only through necessity.

The natives of Issheyuk on the Colville, eat a white clay at times. There is also an edible clay found in the Putnam valley. It is eaten by mixing with oil, berries and leaves. Some of this clay I found at the coal deposit. It was tasteless and easy to swallow. It is only taken when short of food. Food is cooked in iron kettles bought from the traders. Otherwise a clay pot from the Selawik country is used.

Feasts are given at certain times, when natives from all the surrounding country come together. Eating is the first object of these entertainments and dancing next. Often a bear is boiled in a wooden trough, the water being heated by throwing in hot stones. Wooden spoons are used but fingers are preferred.

Tobacco.—Tobacco is used to excess by both sexes. It is taken as snuff; chewed and the juice swallowed, and is smoked. The smoking pipe is a small metal or wooden bowl with a long thick, carved stem of ivory, bone or wood. A small pinch of tobacco mixed with a little deer hair is placed in the bowl, three draws empty it. The smoke is taken into the lungs and kept there some time, producing exhaustive attacks of coughing resulting frequently in complete prostration. This is not objected to and is repeated about every hour of the day and often during the night.

The stronger the tobacco, the more it is relished. One of the first instructions to children is how to smoke and chew. It is customary for the mother to take her babe from the breast and put her pipe or quid of tobacco in its mouth.

Fires are lighted by flints and steels; a kind of cotton is used as tinder. It is gotten from the willow and rendered more inflammmable by soaking in a gunpowder solution.

Native Astronomy and Time Reckoning.—It is held by the natives that the sun stands still and the world goes around it for the reason that the sun at stated periods appears always in the same place. The sun always produces heat; but its great distance from the earth during the winter prevents the heat reaching it. The moon moves and produces cold. The stars are stationary. The "Great Bear" called Toot-to-go-roak, like a big deer, is their favorite constellation and its motions are carefully watched. It is used to indicate direction. The morning star, Ar-go-roak, a favorite, is of use on account of its time of rising. Shooting stars, Ig-neck-pal-luck, are noticed but serve no purpose. They measure time by sleeps and moons. The number of sleeps in a moon is not known, one day is a sleep. A moon is a month and there are thirteen of them in a year. The first, which was in January (1886), they called Shack-kin-na-che-uck, because the sun is coming back. The second moon, She-con-na-shug-u-ruck, because the sun has high altitude. The third moon, Ku-she-wuck-tag-gu-wick, because the snow begins to melt. The fourth moon, Kel-ler-rick-tut-ker-at, because the owl (Kellerick) first appears. The fifth moon, Tong-me-ret-tut-ker-at, because the geese (Tongmeret) come. The sixth moon, See-kur-ur-gu-wick, because the ice (Seekur) begins to break. The seventh moon, Ir-ger-ne-wick, because the birds lay eggs. This moon is also called Et-cher-wick, the birds are moulting and cannot fly. The eighth moon, Neg-ga-lar-lig-it-et-char-re-at, because the young geese (Neggalarligit) cannot fly and the old geese (Etcharreat) have no wing feathers. The ninth moon, Ar-make-uk-se-wick, because the deer horns have velvet on them. The tenth moon, Ar-rup-tut-ker-at, because the water begins to freeze. The eleventh moon, Nue-le-ar-gu-wick, because the deer cohabit (nuele, wife, arguwick, deer). The twelfth moon, November, Nue-ge-ru-erk-see-wick, because horns drop. The thirteenth moon, Pon-dru-wick, because the sun cannot be seen.

CONCLUSION.

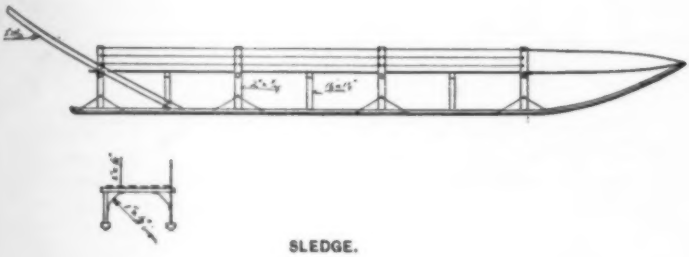
As stated previously, the U. S. Revenue Cutter Bear had anchored off Cape Blossom on July 20, during my absence at Selawik lake. Arrangements were then made for her calling again later and taking us home. On Aug. 9 we loaded the boats and began moving from Camp Purcell to Camp Relief at Cape Blossom on Kotzebue sound, to await the arrival of, and be ready for transfer to the relief vessel. Bad weather interfered so that camp was not thoroughly established until Aug. 18. Aug. 23 the "Bear" again came to anchor off Camp Relief. Ensign Howard and his Point Barrow party were on board, all well. The next day the work of embarkation was begun and by the night of Aug. 25 all hands and all stores were on board. We hoisted in the "Helena" but decided to tow the "Explorer" astern. Aug. 26 the "Bear" sailed for Behring strait and the south, arriving at St. Michael's Aug. 28. Here I left Aloka, the interpreter, Bill and Riley, and their families. We hauled the "Explorer" up on the ways by laying timbers on the beach and using tackles, and I sold her, according to instructions, to Chas. Peterson, of St. Michael's, for $2000. On Sept. 4, the "Bear" left St. Michael's, and ten days later anchored in Ounalaska harbor. I rated the chronometers and we left on Oct. 10 for home. I arrived at San Francisco Oct. 21 and reported at Mare Island Oct. 25. Nov. 9, 1886, the "Northern Alaska Exploring Expedition" was put out of commission, and I was ordered to report to the Secretary of the Navy.

The Northern Alaska Exploring Expedition was in existence one year, six months and fourteen days. From the time we landed from the "Viking" until we went aboard the "Bear" on our return trip, we were four hundred and eight days in the country, during almost every day of which time we were actively engaged in hard work, walking, rowing, tracking, surveying, housebuilding, sledging, etc.

Sledging excursions were out from the fort twice for more than a month at a time, during a total of two hundred and seventy-three days, covering some 3000 miles of journeyings.

During the whole period there was not an accident or a case of illness of any kind, though the life was one of unusual hardship and unceasing exposure, often in a temperature seventy de-

grees below zero. Each officer and man entered into the spirit and purpose of the work with cheerfulness and determination, and each and every one did his duty well, and in a manner worthy of the highest commendation, and I take this opportunity of again thanking them. Nor should the natives be forgotten. They were honest, willing and obedient, and of incalculable service to the expedition. I also again tender my warmest thanks to Captain M. A. Healy, U. S. R. M., commanding; Lieutenant O. Hamlet, U. S. R. M., executive officer, and the other officers of the U. S. Revenue Cutter Bear for their kindness and consideration shown to the officers and men of the expedition on our passage south with them.



SLEDGE.

TEMPERATURES ON THE PUTNAM RIVER, ALASKA.

JULY, 1885.

Lowest temperature during month	32° F.
Highest " " "	70
Mean " " "	49

AUGUST, 1885.

Lowest temperature during month	32° F.
Highest " " "	68
Mean " " "	47

SEPTEMBER, 1885.

Lowest temperature during month	5° F.
Highest " " "	69
Mean " " "	39

OCTOBER, 1885.

Lowest temperature during month	— 4° F.
Highest " " "	46
Mean " " "	16

NOVEMBER, 1885.

Lowest temperature during month	—44° F.
Highest " " "	15
Mean " " "	— 9.5

DECEMBER, 1885.

Lowest temperature during month	—65° F.
Highest " " "	29
Mean " " "	—12.4

JANUARY, 1886.

Lowest temperature during month	—70° F.
Highest " " "	31
Mean " " "	—13.5

FEBRUARY,* 1886.

Lowest temperature during month	—65° F.
Highest " " "	26
Mean " " "	—22.5

MARCH, 1886.

Lowest temperature during month	—38° F.
Highest " " "	36
Mean " " "	— 3.8

APRIL, 1886.

Lowest temperature during month	—22° F.
Highest " " "	49
Mean " " "	13

* Mean temperature February 1st to 20th—33° F.

MAY, 1886.

Lowest temperature during month				.....	14° F.
Highest	"	"	"	.....	65
Mean	"	"	"	.....	35

JUNE, 1886.

Lowest temperature during month				.....	32° F.
Highest	"	"	"	.....	74
Mean	"	"	"	.....	49

NOTE.—During the month of December, 1885, in one hour the temperature rose 29° F, barometer remaining quite steady. This sudden rise in temperature was closely followed by a terrible gale of wind. The thermometer, not the barometer, indicates an approaching gale. It is dead calm when the thermometer stands low, and during the gales the temperature always goes above zero. The more sudden the rise of thermometer the harder the wind blows and the more quickly it hauls. One should watch the thermometer closely and get under shelter if a gale is coming; for neither man nor dog can stand these gales. You must be under shelter. Have seen it snowing—that is a fine snow falling—when there was not a cloud in the sky and very light wind. It is advanced by some that there was a higher wind that carried the snow from the mountain peak.

When the thermometer is minus, it is denoted (—).

The temperatures during the months of July and August were taken partly at Fort Cosmos and while at work on the river. The others were taken at Fort Cosmos and an accurate temperature taken every hour by spirit thermometers remaining outside. These were the best (registered) spirit thermometers, made specially for the government for Arctic observation.

A person can't be too much impressed with the importance of watching the thermometer. I would recommend that the spirit thermometer have the liquid colored, as the white liquid is hard to read. The thermometer should also be protected by a wooden case, leaving only the bulb exposed, and even that should be screened. My observations were the mean of three excellent spirit thermometers.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE TORPEDO-BOAT, DESTROYER, AND DEPOT.

By LIEUT. O. W. KOESTER, U. S. N.

Two great points must be considered before we can have an efficient torpedo fleet: (*a*) efficient boats, (*b*) efficient personnel. In regard to an efficient fleet, it is at first necessary that a torpedo depot be at once established. This depot should be situated on some harbor south of, or near New York, or in fact in a climate where drills can be carried on daily, irrespective of the weather. At this depot should be machine and boiler shops, foundry, torpedo repair shops, air compressor room, store-houses, magazine, armory. Quarters for officers attached to the boats and barracks for their crews. No officer or man should be required to sleep or mess on board a boat except during the manœuvres of the torpedo fleet, or at certain other times as desired in order to accustom the men to life on a torpedo-boat. The depot should be supplied with a marine railway capable of hauling out boats of about 400 tons displacement, and another railway connecting with, and perpendicular to, the marine railway should be built, so that the boats when hauled out for repairs, or to be laid up, may be run clear of the marine railway and at the same time can be put into the water at very short notice. All shops and store-houses should be built close to this railway, as should also be the barracks for the crews. The depot should have a floating derrick capable of lifting 25 to 30 tons. Diving apparatus and skilled divers should be ready at the depot, and when not actually at work, could be utilized in instructing the crews of the boats. There should be a large coaling dock where at least five boats can coal at one time; and the coaling of all boats should be done by laborers from the torpedo depot.

There should be a good harbor near the depot where drills can be carried on. This harbor should have at least six fathoms of water, be free from strong tides and currents, and have, if possible, a sandy bottom. Torpedoes frequently fail to run, and if the above conditions do not obtain, much time will be lost in recovering them.

The boats should be of two types: (*a*) the destroyer, (*b*) the sea-going torpedo-boat. The destroyer should be from 300 to 400 tons displacement and have a maximum speed of 30 to 31 knots. The torpedo-boat should be from 130 to 140 tons displacement with a speed of 25 knots. All boats should be kept in commission constantly, not only to keep the men properly drilled in their duties, but to keep the boats in their highest state of efficiency. A boat laid up for any length of time, even if in an efficient condition, requires much readjustment and examination before she can again be placed in service where maximum speed is required. For instance, joints of various steam pipes will dry out and leak, valves will rust or get dirty and require overhauling, air compressors will have to be overhauled, etc., whereas if the boats be kept in commission this is looked after by the crews, and the boats are constantly ready for service.

All destroyers should be exactly alike in every respect as should also be the torpedo-boats. All should have twin screws and triple expansion engines of either the three- or four-cylinder type, preferably the latter; the engines of either type when running at maximum speed should not make over 375 revolutions per minute. When engines run at much over 350 revolutions per minute the chances of accident increase rapidly.

The type of engine and boiler should be decided upon with great care, taking into consideration first of all the efficiency of the boat as a whole, and when once decision is reached it should be rigidly and carefully carried out, so that boats of a certain type will be exactly alike in every respect to the minutest detail. This is absolutely necessary for efficiency, as men who have qualified for torpedo service will be at once available for duty on any boat, and time will not be lost in teaching men their duties. All parts of each type of boat will then be interchangeable, spare parts, tools and fittings can then be kept in store and ready for immediate use. All supplies can be kept on hand and both efficiency and simplicity obtains.

All spare parts should have a number, together with an initial designating to which department it belongs. For instance, E-5-1 would be a connecting rod, starboard engine, 1st or H. P. cylinder; T-2, a part of a torpedo, etc. These articles, as well as supplies, should be drawn from store without requisition, the commanding officer of the boat deciding what is necessary and receipting for same.

A type of valve gear for the main engines should be adopted, having the fewest number of moving parts, thereby greatly reducing the liability of accident. The efficiency of the entire boat must be considered above the efficiency of any special part, regardless of any special economy of that part. No torpedo-boat can be run with any great degree of economy, and the highest state of efficiency should be sought irrespective of any slight saving of fuel or supplies. The boat is not built for long distance steaming nor for comfort; and her steaming radius does not depend on the amount of coal she can carry, but upon the amount of fresh water necessary and the endurance of her crew. A torpedo-boat steaming at maximum speed uses about six tons of extra feed-water per 1000 H. P. per 24 hours, so it can be readily seen what an important item fresh water is. At a speed of 10 or 12 knots the torpedo-boat can generally carry fresh water to equal her coal endurance; that is, providing the evaporator is kept going constantly. The ordinary torpedo-boat cannot steam at full speed much over 4 hours before the water supply is exhausted.

All dynamos and anchor engines should be retained in the destroyers and removed from the torpedo-boats. The anchors of a torpedo-boat can be handled easily by the crews, and the engines in addition to heating up the meager living spaces of the crews, occupy valuable space and weight. Put the extra weight into the air compressor, rather than into a dynamo or anchor engine.

No deck gratings of any kind should be fitted on the boats of either type as they only add unnecessary weight. Supply the crew with rubber-soled shoes and the same result is obtained in a much more satisfactory way, and at the same time about a ton of weight is saved. Make the signal mast of ordinary brass pipe instead of wood, thereby saving much weight. The deck over the boilers should be secured with bolts, so that it may be

easily removed and boilers can be hoisted out for repairs. A large hatch should be fitted over each engine, in order that proper ventilation may be obtained, and opportunity given for overhauling the engines.

In regard to the personnel. Each destroyer should be commanded by a Lieutenant, with two Junior Officers, one for deck duties and one for engineering duties. These officers should exchange duties every six months, so that they may qualify for any duty. A gunner should also be attached to a destroyer. All of the deck force should consist of gunners' mates and seamen gunners only; in this case each man of the deck force will understand the care and maintenance of the battery, torpedoes, and their appliances, and efficiency and simplicity prevail. In the education of seamen gunners it is absolutely necessary that they be trained in a machine shop, and all chief gunners' mates should at least be able to qualify as first class machinists. The engineer's force of a destroyer should consist of two warrant machinists, and a sufficient number of the following rates: chief machinist, oiler and water tender. No 1st or 2d class machinists nor 1st or 2d class firemen or coal passers should be on board. All machinists and men of the fire-room force should stand the same watch, the latter being required to attend water while on duty, and men doing the duty should have the rate and pay for same.

The torpedo-boat should be commanded by a Lieutenant, with a Junior Officer for both deck and engineering duties as his assistant. One warrant machinist should be attached to a torpedo-boat and all deck men should be gunners' mates and seamen gunners, while the engineer's force should consist of chief machinists, oilers and water tenders.

No man should serve on a destroyer until he has had at least three months of service on a torpedo-boat and has qualified for torpedo service.

Men who have qualified for service in the torpedo fleet should receive, while doing duty with the fleet, 25 per cent. extra pay of their rate, and wear some distinguishing mark on the sleeve. They should be supplied yearly with the following articles free of charge: 2 pairs of working clothes, 2 pairs rubber-soled shoes, 2 watch caps, one suit of oil skins (deck force), one pair gum boots (deck force).

All spare parts and supplies not used daily should be stored on shore, and weights kept down as much as possible in order that the boats may be kept at their designed displacements. In case any improvement be determined for a type of boat, these improvements should be carried out at once in the entire lot of boats, thus keeping the boats alike in all details as far as it is possible to do so. The most vital point of our torpedo service is frequently lost sight of—efficiency first, and economy second. Any appliance for war purposes, if good, is cheap at any price.

NOTE.—Discussion on this article is invited, to be published in succeeding numbers.—EDITOR.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NOTES ON THE MARCONI WIRELESS TELEGRAPH.

By LIEUT. J. B. BLISH, U. S. N.

Last September Mr. G. Marconi, the inventor of a practical system of wireless telegraph, brought over from England three sets of his apparatus for the use of the New York Herald in reporting the international yacht races.

The Navy Department detailed four officers to observe the working of the wireless telegraph during the races, and then, the reports of these officers being favorable to it, accepted Mr. Marconi's offer to set up his instruments on board of ships of the navy and there demonstrate their seagoing qualities and the adaptability of his system to naval signaling.

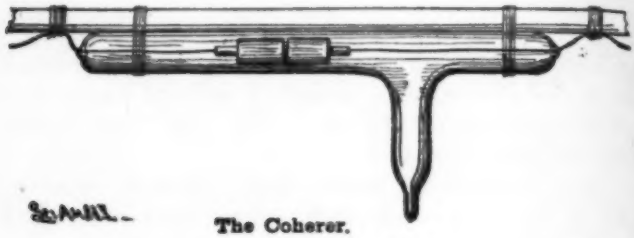
The three sets were installed on the flagship New York, the Massachusetts, and at the Navesink Highlands Light Station; and after a series of tests lasting over a week, three days of which the ships were at sea off Sandy Hook, the torpedo-boat Porter was fitted out with the apparatus from the New York, and spent a day steaming about the Massachusetts and off the Highlands for a further test.

Mr. Marconi then returned with his apparatus to England.

A board of three officers investigated the system during the navy tests, and in their report to the Chief of the Bureau of Equipment recommended that it be given a trial in the navy. During these tests the instruments were open to the inspection of the officers, except certain parts which were never dismounted; and their workings were explained in a general way, but the exact dimensions of the parts were not divulged.

The coherer, the principle of which was discovered some twenty years ago, is the only electrical instrument or device contained in the apparatus that is at all new.

Marconi's coherer, Fig. 1, is a glass tube about an inch and a half long, with a bore about one-tenth inch, into which are fitted two silver plugs, with leading wires attached. The space of about one-twentieth inch between the inner ends of the plugs is partly filled with a mixture of nickel and silver filings. The tube, after being exhausted to about one-thousandth of an atmosphere, is sealed. As shown in the figure, the coherer is seized to a glass rod for convenience in securing it in place in the receiver.



The Coherer.

FIG. 1.

In their normal condition the "imperfect electrical contact" of these filings offers an infinite, or nearly infinite, resistance to a current of low electromotive force, but when the filings are "cohered" their resistance falls to a few hundred ohms, and so remains until they are "decohered," when they instantly resume their non-conducting state.

This coherence is brought about by certain phenomena, which are attendant upon the production of an electric spark and which act through space; the "decohering" is done by mechanically shaking or tapping the coherer.

In the Marconi system a series of sparks produced at the sending station "cohere" the coherer at the distant receiving station, which closes a local circuit containing the coherer, a single cell and a telegraph relay, which closes another circuit containing the tapper and the registering instrument. The instant the sparking ceases, the coherer is "decohered" by the tapper, and both local circuits are broken. Thus the dots and dashes of the telegraph code made in the spark-producing circuit at the sending station are reproduced as short and long closings of the local circuits at the receiving stations, and are registered as dots and dashes on the tape.

This transmission seems to be instantaneous.

Marconi discovered that the distance of transmission was increased enormously by using vertical insulated conductors, both for sending and for receiving; in sending, the vertical wire is connected to one pole of the spark-producing instrument and an earth wire is connected to its other pole; at the receiver, the vertical wire is connected to one leading wire of the coherer, while its other leading wire is connected to earth. This arrangement, shown in Fig. 2, has transmitted signals 25 miles.

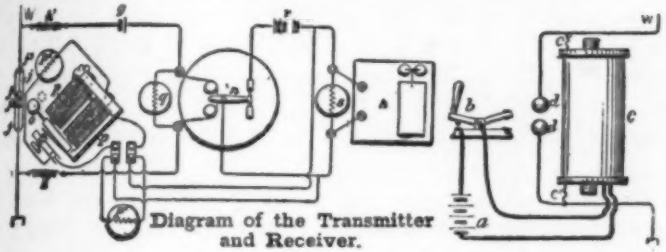


Diagram of the Transmitter and Receiver.

FIG. 2.

Later it was discovered that by replacing the coherer by the primary of a transformer coil and putting the secondary of this coil in series with the coherer, the distance of transmission was again increased manifold.

The Marconi apparatus of to-day is illustrated in Fig. 3, and is diagrammatically represented in Fig. 4, which is reproduced by the permission of the Chief of the Bureau of Equipment from the diagram contained in the report of the Marconi board and which Mr. Marconi pronounced to be correct.

Referring to this diagram:

A is a sheet-iron box, 1/20-inch thick, about 24 inches long, 8 inches wide, and 8 inches high, containing the transformer MM^1, coherer *j*, tapper *p*, relay *n*, relay cell *g*, and battery *r*, for the tapper and register circuits. There are usually two of these receiver boxes at each station; one adjusted for long range work, and the other for shorter ranges. They are connected to earth by the wire from *E*. The box shields the receiving apparatus from all outside electrical influences, except that brought in by the receiving wire.

a is the sending battery, giving a current through the primary of the sending coil, *w*, of about 6 or 8 amperes, at about 17 volts.

The current may be taken either from a battery or from a dynamo circuit, direct or transformed, but usually a storage battery of 8 cells in series is employed on account of the steadiness of its current. This may be recharged from time to time, but continuous charging by a dry-cell battery of slightly higher E. M. F. has been found to give the best results. For this purpose a battery of 98 Obach dry cells, arranged in 7 rows in multiple and 14 in series, is joined in multiple with the storage battery.

b, the sending key, differs from an ordinary telegraph key in having a very long gap between its contacts, made necessary by the large sparks produced between them by the self-induction of the heavy current. These contact points are large and the rubber handle of the key is long. The back-stop of the key connects the vertical wire, *H*, to the receiver, so that after "calling" a station or sending a message by merely letting go of the key, the receiver is connected up ready to take down the answer or acknowledgment from the other station. This automatic connection is seldom used, however, it being preferable to shift the vertical wire by hand from the sender to the receiver.

The limit of speed in sending with this key, is about twelve words per minute; to send faster than this the vertical movement of the key must be shortened, and if shortened too much, the spark is not broken when the key is raised, which not only sends a false signal, but scores up the contact points until they either fail to make the next contact, or making it, they weld together and stick.

During the time that the circuit is closed at the key, the primary current is made and broken at the rate of about forty times per second by the spring circuit-breaker and sparks pass between the ball terminals, *e*, of the secondary of the coil, *W*.

This coil, known as App's 10-inch coil, is similar to the Ruhmkorff coil, and contains the condenser, *Y*, in its base. One of the terminal balls is connected to earth at *E;* on board ship this connection is made to the hull and must be well soldered. The vertical wire is connected to the other terminal.

The distance between these balls is varied from a half-inch to an inch; the range of transmission seems to increase with the length of the spark, but the sending must be done very slowly when the distance is greater than eight-tenths of an inch, otherwise many of the dots will fail to produce any spark at all. Any

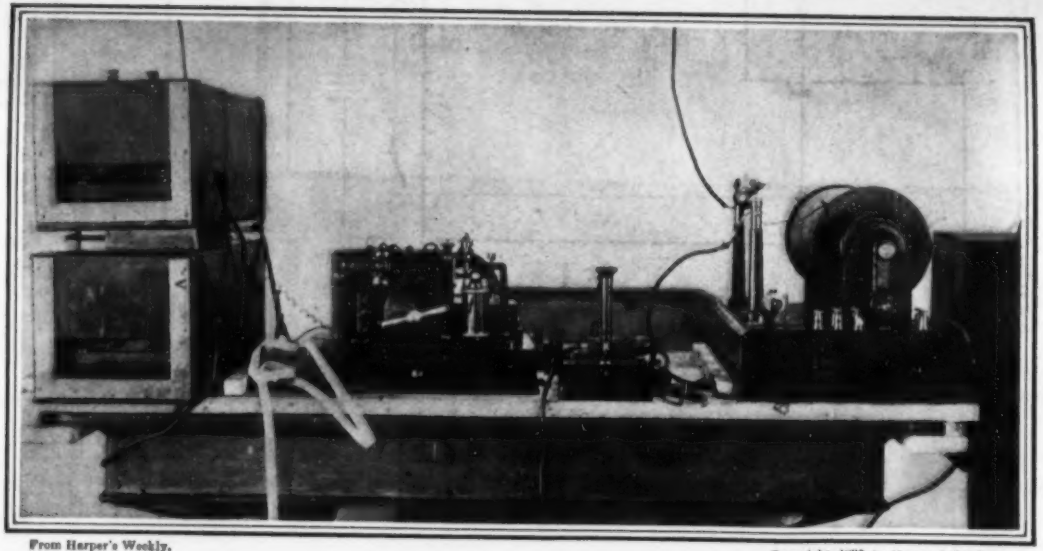


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FIG. 3. THE MARCONI APPARATUS.

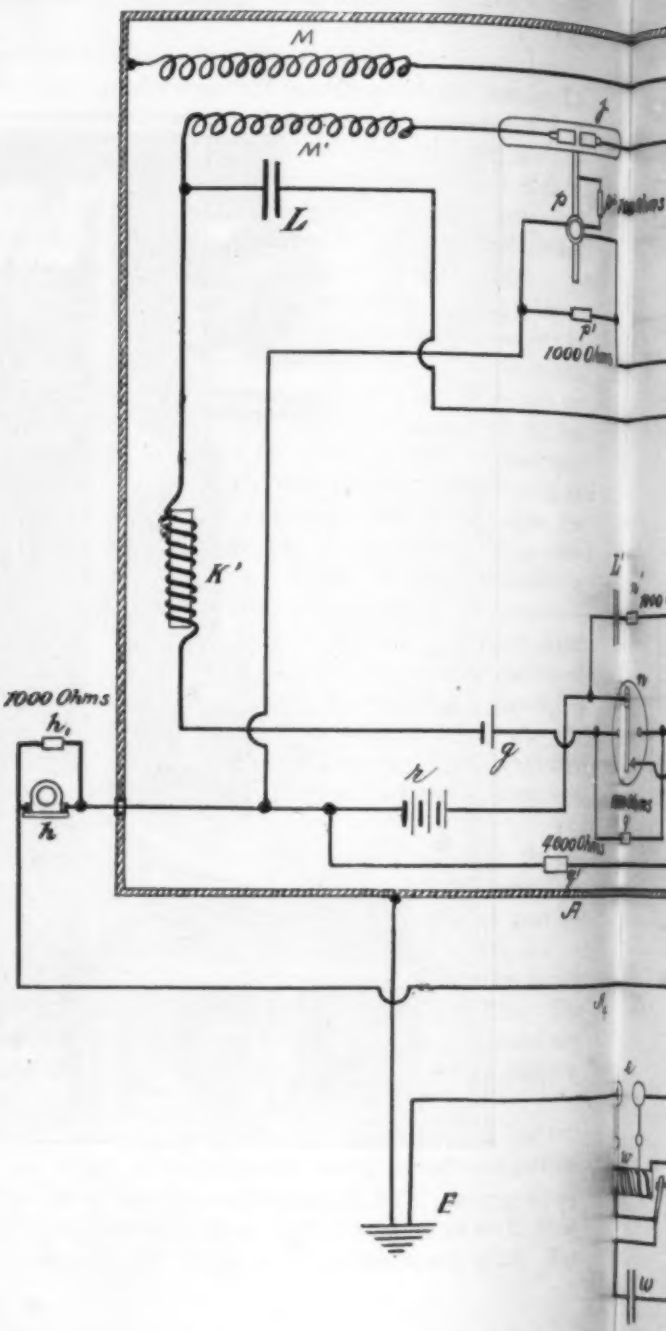
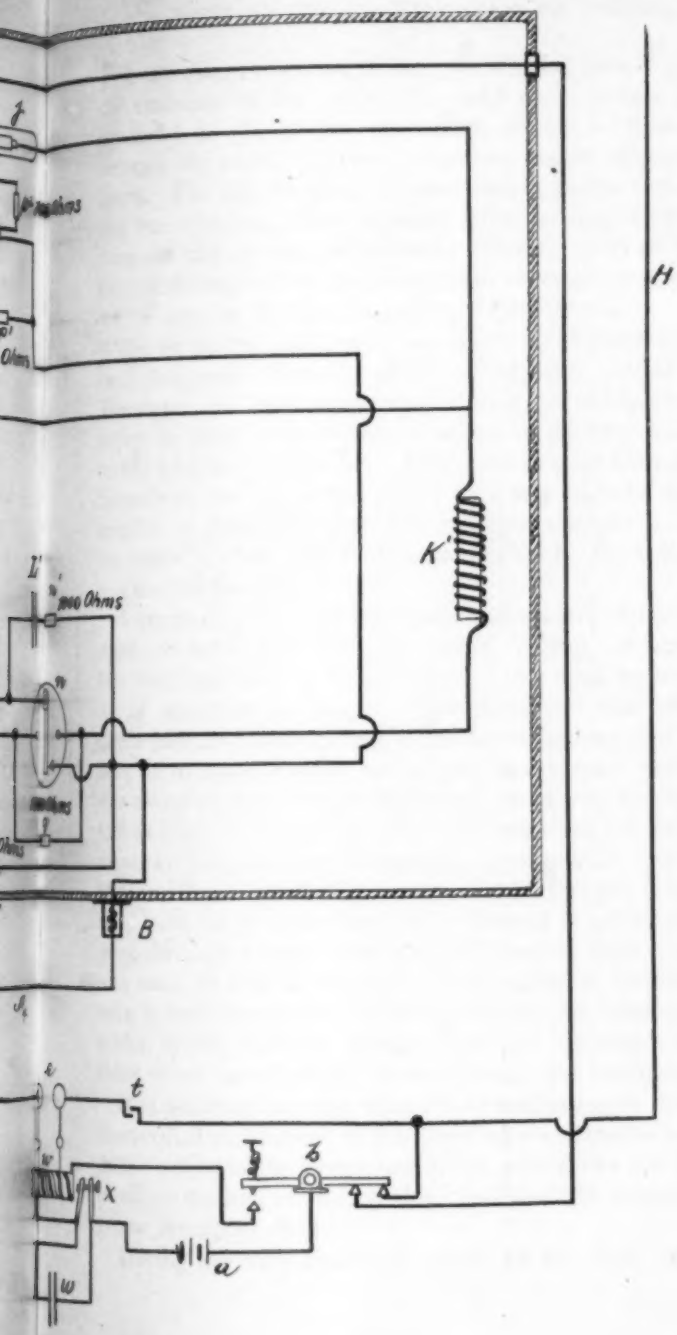


FIG. 4 CONNECTING



WIRELESS TELEGRAPHY.

serious leakage from the coil or the vertical wire is indicated by the character of the spark; if a dead earth occurs no spark is produced at all, as the secondary circuit is then completed through the earth. A sharp crackling sound indicates the best spark. The sparks seem to pass always in the same direction, and one terminal becomes warm from sending, while the other does not change its temperature. The direction of the primary current through the coil is sometimes reversed in order to equalize the wear on the contact points of the vibrator.

The vertical or aerial wire was made up of seven copper wires, each 1/25-inch diameter and covered with rubber insulation. The upper end had an eye spliced in it, to which was secured a string of three or more round sticks of ebonite, each about 18 inches long and 1 inch thick, with holes in their ends for lashings. Sometimes the upper end of the wire was bighted up in several lengths of about two feet, and sometimes it was coiled up in a few turns of about one foot diameter; but no particular attention was paid to that part of it.

A temporary wooden mast was sent up and lashed to the topmast and fitted with hemp or manila rigging. A sprit about 18 feet long was hoisted to the truck of this mast by halliards bent on at one-third its length. The short end was steadied by a down-haul and the wire was triced up to the long end by halliards bent on to upper ebonite sticks, so that the upper end of the wire was above all metal masts, lightning conductors and wire rigging, and as high as it could be got. The wire was led away from the mast, keeping it clear of rigging, smokestacks, davits and the like, to a hatch or skylight; wherever it changed direction, guys of ebonite sticks were bent on to keep it in place, and where it went through a hatch, skylight, bulkhead or door, a rubber tube was used to lead it through. The matter of insulation of this wire is very important; in damp weather the number of ebonite sticks in the various strings must be increased. Sometimes these wires have been led down through the ventilators.

It is believed that the distance of transmission depends upon the vertical component of the aerial wire and varies as the square of the height of the upper end of the wire above the instruments, or above the hull of an iron ship when the instruments are placed below the upper deck.

During the navy trials this height on the New York was 130

feet, on the Massachusetts 140 feet, at Navesink 150 feet, and on the Porter 45 feet.

The height of a shore station above the sea-level or above the surrounding country does not seem to affect its range.

A person touching the wire when it is transmitting receives a severe but not dangerous shock.

The spark at the coil, or even one produced by a bad leak from the wire to earth, would set fire to an inflammable mixture of gas or other easily ignited matter.

There would seem to exist a danger of lightning being conducted below by the wire, but as it offers an unbroken metallic path to earth, possibly, by continuously discharging during an electrical atmospheric disturbance it may act as a protection from lightning. No casualties have been reported from lightning. Atmospheric electricity has been known to cohere the coherer, but the occurrence was never sufficiently frequent to prevent signals from being read.

The receiving wire takes up the impulses sent out by the sending wire and transmits them through the primary, M, of the transformer to earth.

The transformer is of the "step-up" type, the secondary coil being longer than the primary, so that the impulses induced in the secondary coil, M', have an increased effect on the coherer. To prevent their passing through the relay coil into the battery and there being dissipated, the choking coils, $K'K'$, are placed in the circuit and an alternative path through the condenser, L, is provided. The choking coils are made of fine insulated wire wound on iron cores, and are known to impede an alternating current. The condenser, L, prevents the relay current from being short-circuited around the coherer, but seems to offer no resistance to the passage of the induced impulses.

The transformer and the condenser, L, were contained in a small wooden box about 7 inches long, 1½ inches wide, and 1½ inches high, fitted with from 5 to 8 binding posts. This box, known as the "jigger," was never opened. Sometimes a small additional condenser was connected up outside of the "jigger."

When the coherer is cohered the relay circuit is completed, and the armature of the relay is drawn over against its stop, and there completes the two parallel circuits from the battery, r,

one through the tapper and the other through the Morse register or ink-writer, *h*.

The tapper has a spring armature like that of an electric bell, and its hammer strikes the coherer a series of rebounding taps. When the impulses cease the next stroke of the tapper decoheres the filings and breaks the relay circuit when the spring of the relay pulls its armature back and so breaks the tapper and register circuits.

The Morse register or ink-writer is of a commercial pattern and prints the dots and dashes on a tape, reeled off by clockwork.

Across the coils of the relay, tapper and register are the non-inductive shunts, q, p^1 and h^1. These consist of fine insulated wire wound "on the bight" on wooden bobbins, and their office is to short-circuit the high potential currents induced in the coils when the battery currents are broken and so prevent their affecting the transformer or the coherer.

The non-inductive shunts, q^1 and p^2, across the contact points of the armatures of the relay and of the tapper, are to prevent the sparking which would otherwise take place there when their currents are broken.

The shunt, n^1, containing the condenser, L^1, is also placed across the contact points of the relay, but its action was not explained.

The leading wires from the back-stop of the key and from the ink-writer are the only ones that enter the receiving box, and to prevent them from transmitting the effects of the sending spark to the receiver at the same station, special devices are employed. The wire from the key is lead-covered, and the lead is soldered to the box where the wire enters. The ink-writer wire enters at *B*, which is an extension on the box containing a choking coil, each layer of which is covered with tin-foil in metallic contact with the box. The other leading wire is itself connected to the box.

The exact dimensions and the proper construction of all these devices have been arrived at by experiment, and the result is a complete and successful system of wireless telegraphy which has been thoroughly tested, during the past year, afloat and on shore and under various conditions of weather. The greatest distance yet covered by it is 110 miles, from Chelmsford, across the English Channel, to Boulogne. The greatest distance sig-

naled across between two ships at sea was 72 miles, during the British manœuvres. There are a number of permanent shore stations in England and the East Goodwin Lightship has been in communication with the South Foreland Lighthouse, 12 miles distant, since Christmas, 1898.

The instruments brought over to this country were not expected to work over about 25 miles during the races, but when put on board the New York and the Massachusetts, they kept up communication for 36 miles at sea, and the Massachusetts read the New York's signals at about 45 miles. The Porter read signals 7 miles from the Massachusetts, and the Massachusetts read the Porter's messages 8½ miles.

Each station receives all signals made within its range, and if two or more send at the same time, the receiving tape is illegible. So that if a ship got within range of an enemy's fleet she could not only read their signals, but, by working her transmitter continuously, could prevent the transmission of signals between the ships of the fleet.

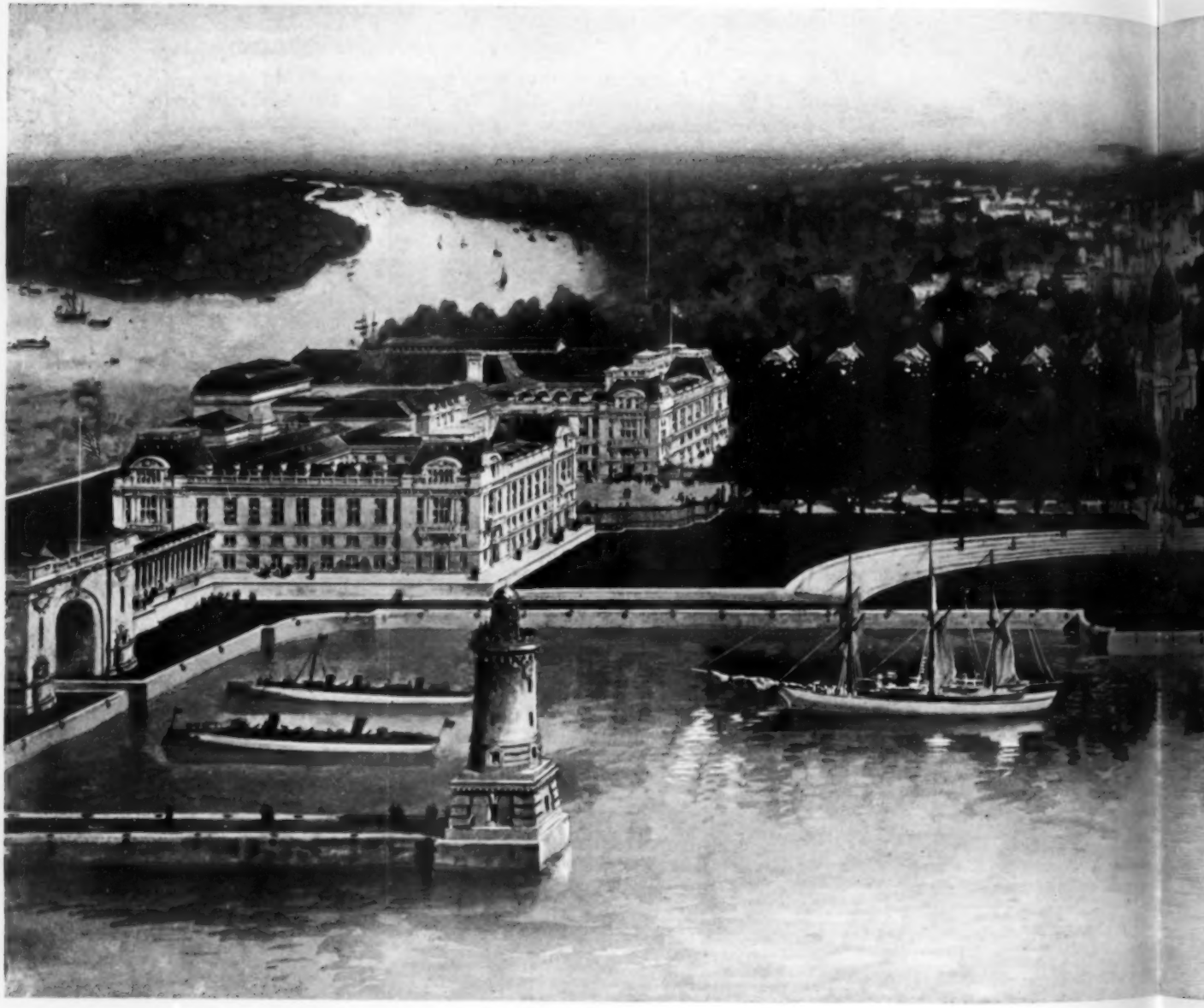
Experiments looking towards the prevention of this interference have been made with partial success, but as it stands to-day interference cannot be prevented.

Another system, based on the use of metallic mirrors without vertical wires, has been developed, but its greatest range being about 1¾ miles it is not adapted to fleet signaling.

The newspapers report that the Marconi system has been adopted by the British army in South Africa and by the British navy; the hulk Hector is to be fitted up at Portsmouth for the instruction of signalmen of the navy.

The incorporation of an American company, controlling the Marconi patents in the United States is also reported.

If adopted by our navy, the care and operation of the apparatus would require about the same intelligence, education and length of special training as are now required for the electric plants on board ship, and a school of instruction should be established as soon as it is decided to adopt the system.



BOAT HOUSE CADET QUARTERS CHAPEL

THE NEW NAVAL ACA

CHAPEL

PHYSICS & CHEMISTRY

ACADEMIC BUILDING

STEAM BUILDING
POWER HOUSE

EW NAVAL ACADEMY

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE NEW NAVAL ACADEMY.

By ERNEST FLAGG, Architect.

The Naval Academy was founded in 1845 when George Bancroft was Secretary of the Navy, and was then located where it is to-day, at Annapolis, Maryland. Some buildings connected with the military post attached to old Fort Severn were pressed into service, and from time to time other buildings were added to them. The old fort stands on the point at the mouth of the Severn river. It is a curious little round structure, having immensely thick walls and a protected entrance from the land side. In recent years a one-story wooden structure has been built on top of the old walls, and the fort now does duty as the gymnasium of the academy. Formerly the water almost washed its base, but from time to time land has been reclaimed from the river, and the structure now stands some distance inside the sea wall. Under the proposed scheme for remodeling the academy, more land will be reclaimed by extending the sea wall on the bay side out to the Port Wardens line and the fort will be thrown still further back. It is proposed to restore this little historic relic to its original appearance, and to mount upon it the old guns, in which condition it will form an interesting feature of the parade ground, and will present a striking contrast to the proposed new practice battery on the point.

From time to time the Government has acquired more land about the old reservation. One of the most important of these acquisitions was the purchase of the grounds with the mansion of the colonial governors of Maryland. The old building still exists and is used as the library of the academy. It has, however, been sadly transformed during the last hundred years. It

has been shorn of its wings, in which were the slaves' quarters, the old porch has been removed from the front and replaced by one not in character with the building, and a heavy new roof has been added, which almost entirely robs the exterior of its former beauty. One roof was burned off. There seems to be no record of the time of this occurrence, but the writer, upon making an examination, found the remains of three roofs, one of which had been very much damaged by fire. The successive roofs have been built one over the other, and it is therefore hardly to be wondered at that the last one looks heavy. The proposed scheme for rebuilding contemplates the restoration of this interesting and historic relic to its original condition, and utilizing it as a residence of the commander of the place, who is known officially as the superintendent. Those who have read Richard Carvel will doubtless remember several references to this old building. When restored it will add greatly to the beauty and interest of the place.

With the exception of the governors' house, and the old fort, there are no buildings of any interest or beauty on the grounds. All are old, poorly built, and many of them are much out of repair. Some have recently been condemned as unsafe, and several have been torn down for this reason. It seems to have been the policy of the Government to build here in the poorest way, and to place the buildings wherever there was a vacant place, with absolutely no regard to the convenient and economical working of the institution. Thus, the armory, which now has one side shored to keep it from falling out, is in a most inconvenient place, almost as far from the parade ground as the limits of the yard will admit, and much time and labor are lost daily in marching and hauling guns by devious paths back and forth between it and the parade ground whenever there is a drill. The recitation buildings seem to have been located by chance, and the boat house, a part of which was condemned as unsafe within five years after it was built, is in a most inconvenient position with regard to the cadets' quarters.

In the scheme for rebuilding, it has been the endeavor to place every building in the location best adapted to it—where it will fit in most advantageously for the routine work of the institution, and most harmoniously from the artistic standpoint.

The flimsy character of the old buildings was amusingly illus-

trated in a story which Admiral Matthews (chairman of the committee which recommended the proposed scheme for rebuilding) told of an experience of his when a boy at the academy. One night when he and some comrades were studying in their rooms in one of the old buildings, they suddenly heard a rumbling sound, the lights were extinguished, there was a rush of cold air, then a terrible crash. One side of the building had fallen out, leaving the rooms open on the side toward the water. Fortunately the floor beams did not rest on this wall, or the admiral would probably not have been alive to tell the story. As it was, the young men found themselves sitting on a shelf in the open air. Recently one of the buildings of this same row was found to be split in two from top to bottom. The two halves seemed to be only held together by the weight of the roof, and it was necessary to rig up great spars and tie the building together with ropes before it could be taken down. In spite of the flimsy character and unsightly appearance of many of the buildings of the academy, the place is attractive, and can hardly fail to produce an agreeable impression upon the visitor. The grounds are always in the most immaculate order. The well-kept walks, fine trees, smooth lawns and beautiful outlook over the bay, all combine to make a most attractive picture and to indicate how beautiful it can be made when all its natural beauties are brought out and the blemishes removed.

The Government owns three pieces of property, comprising several hundred acres, which are more or less disconnected, but which are set apart for the purpose of the academy. The principal one of these, and where it is proposed to place all the new structures, adjoins the town of Annapolis and occupies the point which is formed by the southern bank of the Severn river, where the latter meets Chesapeake Bay. It has a frontage on the bay of about 1200 feet, and a frontage on the river of about 2400 feet. These two water-fronts form an acute angle, so that the property is wider at one end than it is at the other. This would not be so if the sea wall along the river followed the true line of the stream, for the channel of the river makes almost a right angle with the Port Wardens line along the bay side. In the scheme for rebuilding, it is intended to reclaim some part of the flats on the south side of the river by building a great pier, upon which will stand the power house, storage warehouse and steam

engineering building, and to dredge out the rest of the shallow area so as to form a basin for the practice boats of the academy; the basin to be partially enclosed by piers following the true line of the river; this will square out the property and bring it almost to the form of a rectangular quadrilateral, having a breadth of 1284 feet, and a length of about 2500 feet. The basin will have a length of 1083 feet and a width of 580 feet. It is proposed to build a fine new sea wall of massive masonry along all this water-front and around the basin.

The academy has two main entrances which stand at the head of two of the streets of the town. Another street at right angles to these runs along the wall. When one enters he faces towards the Severn river. At present the view of the river, which is very pretty here, is obstructed by a row of unsightly coal sheds and wooden buildings which line the water-front. It is proposed to remove all these and to open up a charming view of the river, with the basin in the foreground, the latter enclosed with massive sea walls of granite, its entrance flanked by stone beacons standing at the ends of the two piers which partially separate it from the river; and the shipping along the quays will produce a striking and characteristic effect. On the southerly side of the basin advantage has been taken of the natural lay of the land to broaden out the quay into a sort of semi-circular place suggestive of an amphitheatre, with concentric rows of broad steps on the banks, which represent the difference in grade between the made land of the quay and the solid ground of the campus. This place will have a length of 415 feet and a width of 250 feet. It is intended for use at out-of-door exercises. The band stand is placed at the center of the side toward the basin. A great multitude could be accommodated on the steps or gradients of the amphitheatre. The fine old trees now on the campus are to be preserved, the lawns extended toward the river, and the parade ground greatly increased by moving the sea wall on the bay side out to the Port Wardens line.

When the proposed plan is carried out the buildings will be in three main groups, one on each of the three sides of the campus, on the other side of which is the basin with its shipping. The cadets' quarters will be on the right hand side as one enters from the town, the academic buildings on the left, and the officers' houses, as at present, on a line parallel to and just inside

the wall which encloses the academy grounds on the side towards the town. The cadets' quarters will stand between the campus and the parade ground. It will be flanked on one side by the boat-house and on the other side by the armory. The main floors of these two latter buildings will be at the level of the parade ground, which, being of made land, is lower than the campus. The cadets' quarters will stand on the higher level, and the difference in grade between the campus on one side and the parade grounds on the other will be made up by a stone terrace about 18 ft. high on the side towards the parade ground, so that the quarters will appear to stand on a terrace when viewed from the parade ground or from the bay.

The boat-house and armory are to be connected with the cadets' quarters by covered ways. The northwesterly end of the boat-house abuts upon the basin, and the main longitudinal axis of the building and the basin coincide.

The academic building at the other side of the campus faces the cadets' quarters; the main axes of both these buildings coincide. They will be connected by a broad avenue of trees. The academic building is flanked on one side by the physics and chemistry building, and on the other side by the steam engineering building. The latter, with the power house and general storage warehouse, form a group which will stand on the reclaimed land at the northwesterly end of the basin. The power house, which is the central building of the three, will face the boat-house at the other end of the basin. Their longitudinal axes coincide with that of the basin.

This general plan, that is to say, the grouping of the buildings, and arrangement of the grounds, and the treatment of the water-front, was prepared by a commission appointed by Secretary Herbert, pursuant to a resolution adopted by the Board of Visitors to the Naval Academy of 1895, requesting the Secretary to appoint a commission "to examine and report upon the condition of the grounds and buildings and the sanitary condition of said Academy." The following extract is from the report of the Board of Visitors:

"The Board feels that the Naval Academy should be an institution second to none of its kind in the world; that it should meet every modern requirement as an institution of learning, not only as to the instruction given, but as to the conveniences and

accommodation offered officers, instructors, and cadets. It feels that the present buildings are insufficient and inadequate for the purposes to which they are assigned, and that a reconstruction of buildings, grounds, and sanitation, upon the most approved modern architectural and sanitary lines, will not only be an incalculable benefit to the naval service, but a progressive step which will meet the approval of the whole country."

A commission was appointed by the Secretary of the Navy, July 5th, 1895, and consisted of Admiral (then Commodore) E. O. Matthews; Captain P. H. Cooper, U. S. N. (then superintendent of the Naval Academy); Lieutenant-Commander E. H. C. Leutze, U. S. N.; Lieutenant-Commander A. Ross, U. S. N.; W. R. DuBose, surgeon, U. S. N.; and W. P. Potter, Lieutenant, U. S. N., recorder.

An extract from the report of this commission reads as follows:

"The Board met at this place on July 16th, 1895, and made a careful inspection of the buildings, grounds and sewerage system. After examining into the needs of the service for which the buildings were erected and the present arrangement and conditions, we find the present buildings are, with few exceptions, in very bad condition and not warranting the expense of the extensive repairs that would be needed to render them safe and serviceable, which repairs would only be temporary, and even then they are so misplaced as to be very inconvenient; others, though now in fairly good condition, will soon begin to require unending repairs, and are so misplaced as to interfere with any proper general plan.

"Owing to the extensive flats surrounding the water-front, which are either exposed at low water or very near the surface, a proper sewerage system is almost if not quite impossible under the present conditions, and the Board, looking to the permanent needs of a great and growing nation, is of the opinion that in the interest of true economy and efficiency, a plan should be adopted for the erection of substantial fireproof buildings of indestructible material, properly arranged and situated, to be convenient, healthful, and thoroughly adapted to the requirements of an institution that is to last for all time.

"Before the erection of the new structures can be commenced the Board deem it of prime importance to install a permanent sanitary sewerage system and to prepare the grounds. This can

only be accomplished by raising existing ground along the water-front and filling in in other places. For that purpose, and at the same time securing sufficient depth of water-front for the handling of boats and vessels used in instruction, dredging should be commenced and a suitable sea wall built."

When the board was appointed it was directed by the Secretary of the Navy that its report be accompanied by a map of the buildings and grounds as now constituted, and also a map of the buildings and grounds as they will appear under the system to be proposed by the board.

A great deal of time, study and care were given to the preparation of this latter map or general plan. The commission met many times on the grounds and carefully considered the needs of the institution and the proper location of the new buildings. Mr. Ernest Flagg, architect, of New York, was invited to assist in the preparation of a plan which should embody the ideas of the board, and his plan was submitted with their report.

The reasons which governed in the preparation of this plan were briefly these:

The area of the grounds was thought to be too restricted. To overcome this and at the same time to deepen the water along the sea walls, it was proposed to reclaim flats which lay under water on two sides, and to obtain the necessary filling by dredging out a part of the area for a basin. By thus raising the general level and deepening the water, the difficulties in the way of the installation of a proper sewer system would also be overcome. In placing the buildings it was thought that as the institution was chiefly for the benefit of the cadets, the cadets' quarters ought to occupy the best and most commanding location on the grounds, that is to say, the site of the present superintendent's residence. There were also other weighty reasons for the selection of this location for the quarters, the most important of which was its proximity to the parade ground, which is admirably located inside the sea wall on the bay side. By placing the boat-house to the northeast of the cadets' quarters, and the armory to the southwest of it, all three of these buildings would be located in the most advantageous positions with respect to the grounds and with respect to themselves. The armory would be contiguous to the parade ground, the boat-house to the basin, and the quarters within convenient reach of each. To still

further facilitate communication between these three buildings, it was determined to connect them by covered ways. It is generally necessary that the cadet should change his clothes preparatory to duties on land or water, it is therefore desirable that the quarters should be within reasonable reach of the boat-house and armory. The plan adopted accomplishes this purpose admirably.

The officers' houses were thought to be well located in their present position, and that when the cadets' quarters are placed on one side and the academic building on the other side of the square upon which they face, no more convenient location could be desired.

The old governors' mansion, which it was desired to preserve both for historical and artistic reasons, seemed to be admirably located for a residence for the superintendent, standing, as it does, at the head of the row of officers' houses. It was thought best to attach the library to the academic building, so that it should be within easy reach from the class-rooms of the various departments. It was placed to the west of and adjoining the academic building, from which it is separated by enclosed courts. The physics and chemistry departments, and the department of steam engineering, each requires separate buildings; these were placed one at either side of the academic building. It was also thought desirable that the steam engineering building should be closely connected with the power house, so that power can be easily transmitted to it, and so that the apparatus of the power house itself might be used for illustration and instruction.

This disposition of the buildings not only has the advantage of bringing every building into the place most convenient for it, but also of placing them where they will produce a fine artistic effect and not interfere with the natural beauties of the place.

Although the report of the Matthews commission was presented January 16th, 1896, no action was taken by the Department until 1898. When the report was made Secretary Herbert thought that, in the then condition of the national finances, Congress would not be likely to enter upon an undertaking of such magnitude as that suggested by the Matthews board. In 1898 the recitation building was found to be unsafe, the Department concluded that something would have to be done, and Congress was asked to make an appropriation to commence the work in

accordance with what was known as the "Matthews plan." Although the sum asked for was stricken out in committee, the House, upon motion of Mr. Mudd of Maryland, agreed to an amendment appropriating $1,000,000 to be applied to the erection of the boat-house, the armory, the power house and a part of the sea wall; $500,000 of this sum was not to be available until the following year. At the next session the secretary was asked for a further sum to commence work on the other buildings, and although committee again failed to include any part of the amount asked for in the bill reported to the House, Mr. Mudd again secured by amendment the appropriation of $720,000 for the work already authorized; $220,000 of this amount was rendered necessary by the determination to make all the buildings of granite instead of brick and limestone as originally contemplated. The plans had been prepared by Mr. Flagg in accordance with the Matthews report. Bids for the work were advertised for and contracts for it were finally made with P. J. Carlin & Co., of Brooklyn, N. Y. The work was commenced March 28th, 1899, and has been in progress ever since. It is expected that the buildings now under erection will be completed in about a year. The Department has asked the present Congress for upwards of $2,000,000 to continue the work upon other buildings of the plan.

DISCUSSION.

"WATCH, QUARTER AND STATION BILLS." See No. 90.

Captain NICOLL LUDLOW, U. S. N.—I commanded the Massachusetts for some nine months or so until June 1st, and Commander Schroeder was the executive during the greater part of that time. The Watch, Quarter and Station Bills of Commander Schroeder I found in use when I assumed command and I found no necessity to make any change whatever in them, neither could I suggest any improvement. The men seemed to readily comprehend them; and this was especially observable, as many new men were coming in as the times of service of the old men expired. I have had considerable experience in making out these bills in times gone by and regard the work of Commander Schroeder as nearly, if not quite, *perfect*. I can suggest nothing to improve on his work and hope that these bills, which are readily applied to any class of vessel, will be made the standard Watch, Quarter and Station Bills of the navy.

Lieutenant ALBERT GLEAVES, U. S. N.—An old sailor recently excused himself for not handling his piece properly by saying, "They changes the drill on me every time I enlist."

It is a common experience that officers returning to sea duty after a tour of two or three years ashore are similarily embarrassed before they have learned not only the new drills, but the new routine, the new duties, the new nomenclature, and even the new uniforms of the chief and other petty officers.

The craze for change is epidemic and demoralizing and it should be discouraged.

There seems now to be no further reason why an organization should not be adopted by regulation and issued to service so arranged in blank as to be applicable to any class of vessels from a gunboat to a battleship, and that proposed by Commander Schroeder seems to be preferable, not only because its flexibility lends itself readily to contraction and expansion, but because it has been proved successful and satisfactory.

In regard to organization, generally speaking, no watch number should exceed three figures; any information that cannot be imparted by three figures can be better obtained in other ways.

It does not seem wise or reasonable to charge the division officer with the care and preservation of the hull. The care of the ship inside and out, properly and legitimately, belongs to the executive officer.

There should be a separate navigator's division. The navigator's detail, so called, when scattered among the gun divisions adds a fictitious

strength only to the division, as they are rarely present at drill or at any other time when they are wanted, there being always a good excuse why they should be somewhere else.

The running and fighting boats' crews should be the same. As it is not desirable to make the fighting boat, when drawn from one division, the running boat, the running boat's crew taken from all parts of the ship should be made the fighting crew. Any objection to this seems to be more than offset by its many advantages. It is not essential that an officer's fighting boat's crew should be the same as his gun's crew, nor is it highly important that his boat should be near his gun; at most it cannot be more than three hundred feet away. There are advantages in bringing an officer into contact with as many men as possible, and it should be as easy to man and arm a boat in one place as another, provided the place is always the same.

Landing should be the only "arm-and-away" service. It alone, as far as I know, with one exception, has been employed by our vessels in the last eighteen months. It is not probable nowadays that the necessity would arise for distant service, and only the most critical situation would justify a commanding officer in hazarding his men and boats from under the protection of his own guns. Such an expedition would be apt to come to grief.

For landing, besides the crew, only sitters (sharpshooters is a more appropriate technical term) will be required, each man in the boat to carry one day's rations. If it should happen that a prolonged stay in the boats or on shore, where rations are not procurable, is demanded, special arrangements could easily be made on the plan now adopted for distant service without encumbering the boat bill with its details, or confusing the men by a list of articles to provide, different for each service, and which neither they nor the officers remember.

The crew for "abandon" ship should be the same as that for arm and away, with the additional extra men. As to "abandon ship," what is urgently needed is more boats and *lighter* boats. It is probable that not a ship in the service can safely carry the crew in her own boats.

It is folly to crowd from thirty to forty into a cutter, to say nothing of "reduced rations for one week," thus bringing down the freeboard to twelve or thirteen inches and destroying its buoyancy. The evolution as now practiced may satisfy the requirements of inspections, but as a matter of absolute utility in time of disaster at sea, it could have only one miserable ending. If, however, it has been decided that the present type of ship's boats has been unalterably fixed, then it would be wise to introduce a "Birkenhead drill," whereby, at least, some of the ship's people would have a fighting chance for their lives. . . .

As to the detail of the engineer division in the powder division, it should be fixed and permanent. The idea of a shifting detail is attractive in theory, but until an engineer's yeoman is found who never shifts numbers without informing the officer of the powder division, it cannot be said to be satisfactory in practice. It is recommended that all of the coal-passers be assigned to the powder division at general quarters,

their duties in the fireroom to be performed by the second-class firemen. This would, of course, reduce the number of "stand-by" stations and would conduce to more efficient service in the fireroom.

This scheme, suggested by Lieutenant S. H. May, U. S. Navy, was tried successfully on the U. S. S. Baltimore during her first commission. . . . It is stated that such a drill was actually practiced on board the U. S. S. Franklin on her famous cruise in Europe. The late Lieutenant-Commander T. B. M. Mason, U. S. Navy, commanded one group of volunteers.

One other point—the marines. It is to be hoped that the experience of the war has definitely settled this vexing question.

Had there been even 5000 marines in transports ready to move on the 21st of April, 1898, I believe that the war, from start to finish, would have been purely a naval expedition, and much history that is now unpleasant reading would never have been written. Co-operation with the army was necessary, and the movement was attended with results that recall Mr. Roderick Random's humerous early English observation on the same subject. The proposition, however, that if marines are to remain a part of the naval establishment they must be excluded entirely from men-of-war and berthed in separate transports to accompany—and subsequently be an additional care to—the fleet was probably not made seriously.

"The Coast Signal System." See page 727.

Lieutenant R. C. Smith, U. S. N.—Lieutenant Anderson deserves the thanks of the navy for his work in connection with the Coast Signal Service, before and during the war, both in Washington and in actual district duty; and lastly for the account he has written of the system for the Institute. The only information hitherto available has been in the official reports, which have not a very wide circulation even in the navy. The paper in question does not so state, but I believe that to Lieutenant Anderson is due the credit of a number of features that became a part of the system as established. As it happened, its workings did not receive the test of war; that is, it had no occasion to report the movements of the enemy's vessels. If there were defects in the system itself, they are not at once apparent to an observer that has no personal experience in the work.

This paper and the report of the Superintendent of the Coast Signal Service in the war do not leave much doubt that the nucleus of such a service should be a permanent peace establishment. If there is any criticism I can make on the paper as it stands, it is that I do not believe it would be expedient to draw on the regular coast signal service so established for reinforcing the navy in time of war and substituting them with naval militia.

This brings up a number of militia questions. The coast signal system is a very important duty in war, and is one of the duties that have been suggested for the militia. There are one or two propositions in connection with our second line of defense, the mere statement of which

seems enough to ensure their acceptance: 1st. Duties such as coast signaling, local torpedo-boat service, harbor-patrol and submarine mining (this does not yet belong to the navy) cannot be most efficiently performed except by men of *local knowledge*, trained in time of peace for these actual duties in time of war. 2d. A reserve of sailors is needed to recruit the navy in time of war. 3d. The militia, by the terms of the Constitution, can be used in only three ways: to execute the laws of the Union, to suppress insurrection, and to repel invasion. If they are wanted to serve in the navy they must leave the militia and volunteer for the navy. 4th. There is an essential difference between the local land militiaman and the local naval militiaman, apart from the element in which he serves. If the land militiaman has been properly trained as a soldier he is fit to serve anywhere as a soldier. If the naval militiaman has been properly trained in local duties connected with his own coast, and is then sent somewhere else, his local training has been wasted.

In view of these four propositions, it seems that we need a naval reserve of sailors to serve anywhere, and a local naval militia to serve only on their own coast. There is an effort now on foot to create a national naval reserve, and it merits the fullest success. The naval militia, to be of the fullest use locally in time of war, should be trained on a comprehensive plan determined by the general government. The States must do the training, as that is one of their rights under the Constitution.

Why not, to ensure all these objects, invite the militia also to enroll, say as local volunteers? There would be then a national body of naval reserves for service anywhere, and a national body of naval volunteers for service on their own coast. To obtain militiamen for these duties, it would be necessary to have an understanding with the separate States, which it is thought would not be difficult. Reserves and volunteers could then serve together in their State militia. It would not be essential to have the reserves join the militia unless they so preferred, but volunteers should all be militiamen in order to get the local training. There would be an annual drill period for both branches under United States supervision, but the individuals would then be United States reserves and volunteers, and not State militia. Thus, apparently, all ends could be subserved, and the constitutional requirements as to militia service and training would not interfere. Some of these questions were discussed more at length in a paper I wrote for the Institute a year ago, entitled "Naval Reserves and Naval Volunteers."

The application of this to the Coast Signal Service is that a peace nucleus could now be established in a few important stations. In war-time some of these men would be distributed to other stations, and full complements would be made up from members of the local naval militia whose training in peace-time had been in this direction, but who would now be serving as United States naval volunteers. Perhaps when the system had attained an efficient working order, the permanent force, who might, perhaps, belong to the national naval reserve, might be withdrawn for sea service; but this would hardly be advisable for the first few months of the war.

Captain C. F. GOODRICH, U. S. N.—There is little to be said on the subject of this paper. Lieutenant Anderson describes a scheme which worked well in all respects. It was put into operation with extraordinary rapidity and maintained efficiently and economically. If another foreign war breaks out, we shall only need to do again what we have already done. Personally, I am glad to have been identified with the Coast Signal Service, if for but a brief period, and to have met the many agreeable men and earnest laborers who made it a success from the start. Lieutenant Anderson is very modest withal. He totally fails to tell us how much of that success is due to his individual efforts.

Lieutenant-Commander J. B. MURDOCK, U. S. N.—The consideration of the yearly problems at the Naval War College has shown most forcibly the necessity of the establishment of some system of coast signal service, in order that the commanders of our fleets in time of war may be advised in good season of any hostile naval force near the coast. The solution of the various problems since 1894 has always included the development of the coast signal service for the region under consideration, and these partial solutions, formed, when united, the foundation of a service covering the whole extent of the Atlantic coast. Previous to the war with Spain it had been pointed out that the naval militia of the various States were well fitted to man and operate stations of this kind, and in 1897 orders were issued by the Navy Department by which certain officers were assigned to the instruction of the various militia organizations in the matter of off-shore signaling, so that, when hostilities began, and the signal service was actually established, very much of the preparatory work had already been considered, and the speedy development and marked efficiency of the service were the natural result.

The actual work of the signal service during the war was limited, as Mr. Anderson states in his article, by the fact that at no time did any hostile vessel appear off our coast. Its capabilities and its efficiency were, however, made manifest, and the absolute necessity of a similar service was made self-evident in case the United States should ever become involved in hostilities with any country having an aggressive naval force. It seems, therefore, that the recommendations of the writer towards the permanent establishment of signal stations at certain points, and the continued training of the State Naval Militia organizations in the operation of these stations, are both matters of the greatest importance. Whatever is to be done in time of war must be prepared for at leisure and carefully in time of peace; as, although stations may be rapidly equipped, the services of trained men cannot be obtained instantaneously.

The development of wireless telegraphy gives the Coast Signal Service a possible efficiency such as it heretofore could not possess. Flags, shapes and Ardois signals are all rendered unnecessary, and all superseded by a vastly more efficient instrument, which is capable also of transmitting information much more rapidly and over very much greater distances. The experiments made on the New York and the Massachusetts have

shown that this system of telegraphy is especially adapted for use afloat; and vessels fifty miles off shore can maintain constant and perfect communication with signal stations on the coast. The cost of installation of the apparatus is probably not excessive, the special training is not arduous; but the probable developments and improvements which will take place within the next few years demand constant and unremitting attention on the part of those who may be detailed to use it. If, therefore, any system is to be adopted, or even the skeleton of a coast signal service kept in existence, officers and men should have constant practice in order to keep familiar with the latest improvements in this work. If each State militia could have two shore stations, each equipped with complete apparatus for wireless telegraphy, the men could be drilled at such seasons as might be most convenient, telegraphing from one to the other, and kept posted in all the advancements and improvements in apparatus, so that, when an emergency arose, a skilled force would already be in existence. Nothing would remain but the equipment and manning of the stations. This could be accomplished very rapidly, and a few days would suffice to equip the whole length of our coast. Without this training in time of peace the establishment of an efficient service would be a tedious service.

It may not be unwise to keep at the stations semaphores for the purpose of communicating with vessels not fitted with telegraph apparatus. In the same way flags and Very lights may be supplied, it being the function of a station to gather information in all possible ways.

If the Government is ever to have, in time of war, a uniform and thoroughly organized coast signal service, its use would mainly be in the transmission of information to or from naval vessels. It should, therefore, be under the control of the Navy Department, and, in time of peace, should be placed under one of the bureaus, which would be charged with the instruction of the various militia organizations, and the formation of plans for the enlargement, development and speedy mobilization of the signal corps in time of war. The war with Spain showed how readily the naval militia could be used for this purpose, how efficient a personnel they would make, and the detail for this duty might greatly improve the morale of the organizations by assigning them to definite responsible duties in time of war, and possibly relieve them of any ambition to perform other duties for which they are less well fitted.

PROFESSIONAL NOTES.

THE BRITISH ASSOCIATION; MECHANICAL SCIENCE SECTION.

Address of the President,* Sir William White, K. C. B., Sc. D., LL. D., F. R. S.

Advantages of Increased Dimensions.

Before passing on, it may be interesting to illustrate the gain in economy of propulsion resulting from increase in dimensions by means of the following table, which gives particulars of a number of typical cruisers, all of comparatively recent design.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Length.....ft.	220	300	360	455	500
Breadth..... "	35	43	60	69	71
Mean draught ..... "	13	16½	23½	24½	26½
Displacement .....tons.	1,800	3,400	7,400	11,000	14,200
Indicated horse-power for 20 knots.	6,000	9,000	11,000	14,000	15,500
Indicated horse-power per ton of displacement.....	3.3	2.65	1.48	1.27	1.09

The figures given are the results of actual trials, and embody, therefore, the efficiencies of propelling machinery, propellers, and forms of the individual ships. Even so, they are instructive. Comparing the first and last, for example, it will be seen that while the displacement is increased nearly eightfold, the power for 20 knots is only increased about 2.6 times. If the same types of engines and boilers had been adopted in these two vessels—which was not the case, of course—the weights of propelling apparatus and coal for a given distance would have been proportional to the respective powers; that is to say, the larger vessel would have been equipped with only 2.6 times the weight carried by the smaller. On the other hand, roughly speaking, the disposable weights after providing for hulls and fittings in these two vessels might be considered to be proportional to their displacements. As a matter of fact, this assumption is distinctly in favor of the smaller ship. Adopting it, the larger vessel would have about eight times the disposable weight of the smaller; while the demand for propelling apparatus and fuel would be only 2.6 times that of the smaller vessel. There will, therefore, be an enormous margin of carrying power in comparison with displacement in the larger vessel. This might be devoted—and in fact was devoted—partly to the attainment of a speed considerably exceeding 20 knots (which was a maximum for the smaller vessel), partly to increased coal endurance, and partly to protection and armament.

Another interesting comparison may be made between vessels Nos. 4 and 5 in the preceding table, by tracing the growth in power necessary to drive the vessels at speeds ranging from 10 knots up to 22 knots.

* Delivered before Section G, Dover Meeting.

	No. 4. H.-P.	No. 5. H.-P.
10 knots	1,500	1,800
12 "	2,500	3,300
14 "	4,000	5,000
16 "	6,000	7,500
18 "	9,000	11,000
20 "	14,000	15,500
22 "	23,000	23,000

It will be noted that up to the speed of 16 knots there is a fairly constant ratio between the powers required to drive the two ships. As the speeds are increased, the larger ship gains, and at 22 knots the same power is required in both ships. The smaller vessel, as a matter of fact, was designed for a maximum speed of 20½ knots, and the larger for 22 knots. Unless other qualities had been sacrificed, neither space nor weight could have been found in the smaller vessel for machinery and coals corresponding to 22 knots. The figures are interesting, however, as illustrations of the principle that economy of propulsion is favored by increase in dimensions as speeds are raised.

Going a step further, it may be assumed that in unsheathed cruisers of this class about 40 per cent. of the displacement will be required for the hull and fittings, so that the balance, or "disposable weight," would be about 60 per cent.; say 6600 tons for the smaller vessel and 8500 tons for the larger, a gain of nearly 2000 tons for the latter. If the speed of 22 knots were secured in both ships, with machinery and boilers of the same type, the larger ship would, therefore, have about 2000 tons greater weight available for coals, armament, armor and equipment.

These illustrations of well-known principles have been given simply for the assistance of those not familiar with the subject, and they need not be carried further. More general treatment of the subject, based on experimental and theoretical investigation will be found in text-books of naval architecture, but would be out of place in this address.

Swift Torpedo Vessels.

Torpedo flotillas are comparatively recent additions to war fleets. The first torpedo-boat was built by Mr. Thornycroft for the Norwegian Navy in 1873, and the same gentleman built the first torpedo-boat for the Royal Navy in 1877. The construction of the larger class known as "torpedo-boat destroyers," dates from 1893. These various classes furnish some of the most notable examples extant of the attainment of extraordinarily high speeds, for short periods and in smooth water, by vessels of small dimensions. Their qualities and performances, therefore, merit examination.

Mr. Thornycroft may justly be considered the pioneer in this class of work. Greatly impressed by the combination of lightness and power embodied in railway locomotives, Mr. Thornycroft applied similar principles to the propulsion of small boats, and obtained remarkably high speeds. His work became more widely known when the results were published of a series of trials, conducted in 1872 by Sir Frederick Bramwell, on a small vessel named the Miranda. She was only 45 feet long, and weighed 4 tons, yet she exceeded 16 knots on trial. The Norwegian torpedo-boat, built in 1873, was 57 feet long, 7½ tons, and of 15 knots; the first English torpedo-boat of 1877 was 81 feet long, 29 tons, and attained 18½ knots.

Mr. Yarrow also undertook the construction of small swift vessels at a very early date, and has greatly distinguished himself throughout the

development of the torpedo flotilla. Messrs. White, of Cowes, previously well known as builders of steamboats for use on board ships, extended their operations to the construction of torpedo-boats. These three firms for a considerable time practically monopolized this special class of work in this country. Abroad, they had able competitors in Normand in France, Schichau in Germany, and Herreshoff in the United States. Keen competition led to successive improvements and rapid rise in speed. During the last six years the demand for a fleet of about 100 destroyers, to be built in the shortest possible time, involved the necessity for increasing the sources of supply. At the invitation of the Admiralty, a considerable number of the leading shipbuilding and engineering firms have undertaken and successfully carried through the construction of destroyers varying from 26 to 33 knots in speed, although the work was necessarily of a novel character, involving many difficulties.

As the speeds of torpedo vessels have risen, so have their dimensions increased. Within the class, the law shown to hold good in the larger vessels applies equally. In 1887 a first-class torpedo-boat was 81 feet long, under 30 tons weight, developed 400 horse-power, and steamed 18½ knots. Ten years later the corresponding class of boat was 135 feet long, 125 tons weight, developed 1500 horse-power and steamed 23 knots. In 1897 it had grown to 150 feet in length, 140 to 150 tons, 2000 horse-power and 26 knots.

Destroyers are not yet of seven years' standing, but they come under the rule. The first examples (1893) were 180 feet long, 240 tons, 4000 horse-power, and 26 to 27 knots. They were followed by 30-knot vessels, 200 to 210 feet long, 280 to 300 tons, 5500 to 6000 horse-power. Vessels now in construction are to attain 32 to 33 knots, their length being about 230 feet, displacements 360 to 380 tons, and engine power 8000 to 10,000 horse-power.

Cost has gone up with size and power, and the limit of progress in this direction will probably be fixed by financial considerations, rather than by constructive difficulties, great as these become as speeds rise.

It may be interesting to summarize the distinctive features of torpedo-vessel design.

1. The propelling apparatus is excessively light in proportion to the maximum power developed. Water-tube boilers are now universally adopted, and on speed trials they are "forced" to a considerable extent. High steam-pressures are used. The engines are run at a high rate of revolution—often at 400 revolutions per minute. Great care is taken in every detail to economize weight. Speed trials at maximum power only extend over three hours. On such trials in a destroyer each ton weight of propelling apparatus produces about 45 indicated horse-power. Some idea of the relative lightness of the destroyer's machinery and boilers will be obtained when it is stated that in a large modern cruiser, with water-tube boilers, high steam-pressure, and quick-running engines, the maximum power obtained on an eight hours' trial corresponds to about 12 indicated horse-power per ton of engines, boilers, &c. That is to say, the proportion of power to weight of propelling apparatus is from three and a half to four times as great in the destroyer as it is in the cruiser.

2. A very large percentage of the total weight (or displacement) of a torpedo vessel is assigned to propelling apparatus. In a destroyer of 30 knots trial speed, nearly one-half the total weight is devoted to machinery, boilers, &c. In the swiftest cruisers of large size, the corresponding

allocation of weight is less than 20 per cent. of the displacement; in the largest and fastest mail steamers it is about 20 to 25 per cent.

3. The torpedo vessel carries a relatively small load of fuel, equipment, &c. Taking a 30-knot destroyer, for example, the speed trials are made with a load not exceeding 12 to 14 per cent. of the displacement. In a swift cruiser the corresponding load would be free from 40 to 45 per cent., or proportionately more than three times as great. What this difference means may be illustrated by two statements. If, in the destroyer, the load were trebled and the vessel correspondingly increased in draught and weight, the speed attained with the same maximum power would be about 3 knots less. If, on the other hand, the vessel were designed to attain 30 knots on trial with the heavier load, her displacement would probably be increased about 70 to 80 per cent.

4. The hull and fittings of the torpedo vessel are exceedingly light in relation to the dimensions and engine power. For many parts of the structure, steel of high tensile strength is used. Throughout, the utmost care is taken to economize weight. In small vessels, for special service, many conditions can be accepted which would be inadmissible in larger sea-going vessels. The result of all this care is the production of hull-structures having ample general strength but very little local strength.

These conditions are essential to the attainment of very high speeds for short periods. They resemble the conditions ruling the design of cross-Channel steamers, so far as relative lightness of propelling apparatus, small load, and light scantlings are concerned. The essential differences lie in the requirements for passenger accommodation, as compared with the requirements for armament of the torpedo vessel. No one has yet proposed to extend the torpedo-vessel system to sea-going ships of large dimensions. Very similar conditions for the propelling apparatus have been accepted in a few cruisers of considerable dimensions, wherein high speeds for short periods were required. It is, however, unquestionable, that in many ways, and particularly in regard to machinery design, the construction of torpedo vessels has greatly influenced that of larger ships.

One important consideration must not be overlooked. For short-distance steaming, at high speeds, economy in coal consumption is of little practical importance, and it is all-important to secure lightness of propelling apparatus in relation to power. For long-distance steaming, on the contrary, economy in coal consumption is of primary importance; and savings in weight of propelling apparatus, even of considerable amount, may be undesirable if they involve increased coal consumption. Differences of opinion prevail as to the real economy of fuel obtainable with boilers and engines such as are fitted in torpedo vessels. Claims are made for some vessels which represent remarkable economy. Only enlarged experience can settle these questions.

Endurance is also an important quality in sea-going ships of large size, not merely in structures but in propelling apparatus. The extreme lightness essential in torpedo vessels obviously does not favor endurance if high powers are frequently or continuously required. Still, it cannot be denied that the results obtained in torpedo vessels show such a wide departure from those usual in sea-going ships, as to suggest the possibility of some intermediate type of propelling apparatus, applicable to large sea-going ships, and securing sufficient durability and economy of fuel in association with further savings of weight.

The Parsons Turbo-Motor.

The steam turbo-motor introduced by Mr. Charles Parsons is to be described by the inventor during these meetings; but it is impossible for me to pass it over in this review without a brief notice. This rotary engine with its very high rate of revolution, reduces the weights of machinery, shafting and propellers greatly below the weight required in the quickest-running engines of the reciprocating type. This reduction in the proportion of weight to power carries with it, of course, the possibility of higher speed in a vessel of given dimensions; and when large powers are employed the absolute gain is very great. An illustration of this has been given by Mr. Parsons, in the Turbinia. That remarkable vessel is 100 feet long, and of 44½ tons displacement, but she has attained 33 to 34 knots in short runs. There are three shafts, each carrying three screw propellers, each shaft driven by a steam turbine making over 2000 revolutions at full speed, when more than 2000 horse-power is developed. A water-tube boiler of special design supplies steam of 175 pounds pressure, and is exceptionally light for the steam produced, being highly forced. The whole weight of machinery and boilers is 22 tons: in other words, about 100 horse-power (indicated) is produced for each ton weight of propelling apparatus. This is rather more than twice the proportion of power to weight as compared with the lightest machinery and boilers fitted in torpedo-boats and destroyers. It will be noted that in the Turbinia, as in the destroyers, about half the total weight is devoted to propelling apparatus, and in both instances the load carried is relatively small. The secret of the extraordinary speed is to be found in the extreme lightness of propelling apparatus and small load.

Two other vessels of the destroyer type with turbo-motors (one for the Royal Navy) are now approaching completion. Their trials will be of great interest, as they will furnish a direct comparison with vessels of similar size and form, fitted with similar boilers but driven by reciprocating engines.

No doubt in the Turbinia lightness has been pushed further than it would be in vessels of larger size and greater power. In such vessels a lower rate of revolution would probably be accepted, additional motors would be fitted for manœuvring and going astern, boilers of relatively greater weight would be adopted, and other changes made. But after making ample allowance for all such increases in weight, it is unquestionable that considerable economies must be possible with rotary engines.

On the side of coal consumption, Mr. Parsons claims at least equality with the best triple-expansion engines. Into the other advantages attending the use of rotary engines it is not necessary now to enter.

Reference must be made, however, to one matter in which Mr. Parsons has done valuable and original work. In torpedo vessels of high speed, the choice of the most efficient propellers has always been a matter of difficulty, and the solution of the problem has in many instances involved extensive experimental trials. By means of alterations in propellers alone very large increases in speed have been effected; and even now there are difficulties to be faced. When Mr. Parsons adopted the extraordinary speed of revolution just named for the Turbinia, he went far beyond all experience and precedent, and had to face unknown conditions. He has found the solution, after much patient and original investigation, in the use of the multiple screws of small diameter. His results in this direction are of general interest to all who have to deal with screw propulsion.

Such radical changes in propelling machinery as are involved in the adoption of turbo-motors, must necessarily be subjected to thorough tests before they will be widely adopted. The experiment which the Admiralty are making is not on a small scale as regards power. Although it is made in a destroyer, about 10,000 horse-power will probably be developed, and a correspondingly high speed attained. It may well happen that from this experiment very far-reaching effects may follow. Mr. Parsons himself has prepared many designs illustrating various applications of the system to sea-going, cross-Channel, and special service vessels. Where shallowness of draught is unavoidable, the small diameter of the screws possible with the quick-running turbines is clearly an important matter.

Comparisons between Large and Small Vessels.

It has been shown that the attainment of very high speeds by vessels of small size involves many conditions not applicable to large sea-going steamships. But it is equally true that in many ways the trials of small swift vessels constitute model-experiments from which interesting information may be obtained as to what would be involved in driving ships of large size at speeds much exceeding any of which we have experience. When the progressive steam trials of such small vessels can be studied side by side with experiments made on models to determine their resistance at various speeds, then the fullest information is obtained, and the best guide to progress secured. This advantage, as has been said, we owe to William Froude.

His contributions to the Reports of the British Associations are classics in the literature of the resistance and propulsion of ships. In 1874 he practically exhausted the subject of frictional resistance so far as it is known; and his Presidential Address to this Section in 1875 dealt fully and lucidly with the modern or stream-line theory of resistance. No doubt there would be advantage in extending Froude's experiments on frictional resistance to greater lengths and to ship-shaped forms. It is probable, also, that dynamometric determinations of the resistance experienced by ships of modern forms and considerable size, when towed at various speeds, would be of value, if they could be conducted. These extensions of what Froude accomplished are not easily carried out; and in this country the pressure of work on shipbuilding for the Royal Navy has, for many years past, taxed to the utmost limits the capacity of the Admiralty experimental establishment, so ably superintended by Mr. R. E. Froude, allowing little scope for purely scientific investigations, and making it difficult to deal with the numerous experiments incidental to the designs of actual ships. Now that Holland, Russia, Italy and the United States have equipped experimental establishments, while Germany and France are taking steps in that direction, we may hope for extensions of purely scientific work and additions to our knowledge. In this direction, however, I am bound to say that much might be done if experimental establishments, capable of dealing with questions of general nature relating to resistance and propulsion, were added to the equipment of some of our universities and colleges. Engineering laboratories have been multiplied, but there is as yet no example of a model experimental tank, devoted to instruction and research.

It is impossible, and possibly is unnecessary, to attempt in this address any account of Froude's "scale of comparison" between ships and models at "corresponding speeds." But it may be of interest to give a

few illustrations of the working of this method, in the form of a contrast between a destroyer of 300 tons, 212 feet long, capable of steaming 30 knots, and a vessel of similar form enlarged to 765 feet in length and 14,100 tons. The ratio of dimensions is here about 3.61:1; the ratio of displacements is 47:1; and the ratio of corresponding speeds is 1.9:1.

To 12 knots in the small vessel would correspond 22.8 knots in the large vessel; and the resistance experienced by the large vessel at 22.8 knots (neglecting a correction for friction) should be 47 times that of the small vessel at 12 knots. By experiment this resistance for the small vessel was found to be 1.8 tons. Hence for the large vessel at 22.8 knots the resistance should be 84.6 tons. This would correspond to an "effective horse-power" of over 13,000, or to about 26,000 indicated horse-power. The frictional correction would reduce this to about 25,000 horse-power, or about 1.8 horse-power per ton. Now, turning to the destroyer, it is found experimentally that at 22.8 knots she experiences a resistance of 11 tons, corresponding to an effective horse-power of over 1700 horse-power, and an indicated horse-power of about 3000 horse-power: say 10 horse-power per ton, or nearly 5½ times the power per ton required in the larger vessel. This illustrates the economy of propulsion arising from increased dimensions.

Applying the same process to a speed of 30 knots in the large ship, the corresponding speed in the small ship is 15.8 knots. Her resistance at that speed is experimentally determined to be 3.5 tons, and the resistance of the large ship at 30 knots (neglecting frictional correction) is about 165 tons. The effective horse-power of the large ship at 30 knots is, therefore, about 34,000, corresponding to 68,000 horse-power indicated. Allowing for the frictional correction, this would drop to about 62,000 horse-power, or 4.4 horse-power per ton. For the destroyer at 30 knots the resistance is about 17½ tons; the effective horse-power is 3600, and the indicated horse-power about 6000, or 20 horse-power per ton, nearly five times as great as the corresponding power for the large ship. But while the destroyer under her trial conditions actually reaches 30 knots, it is certain that in the large ship neither weight nor space could be found for machinery and boilers of the power required for 30 knots, and of the types usually adopted in large cruisers, in association with an adequate supply of fuel. The explanation of the methods by which the high speed is reached in the destroyer has already been given. Her propelling apparatus is about one-fourth as heavy in relation to its maximum power, and her load is only about one-third as great in relation to the displacement, when compared with the corresponding features in the cruiser.

The earlier theories of resistance assumed that the resistance experienced by ships varied as the square of the speed. We now know that the frictional resistances of clean-painted surfaces of considerable length vary as the 1.83 power of the speed. This seems a small difference, but it is sensible in its effects, causing a reduction of 32 per cent. at 10 knots. On the other hand, it is now known that the laws of variation of the residual or wave-making resistance may depart very widely from the law of the square of the speed, and it may be interesting to trace for the typical destroyers how the resistance actually varies.

Take first the total resistance. Up to 11 knots it varies nearly as the square of the speed: at 16 knots it has reached the cube: from 18 to 20 knots it varies as the 3.3 power. Then the index begins to diminish: at

22 knots it is 2.7: at 25 knots it has fallen to the square, and from thence to 30 knots it varies practically as does the frictional resistance.

The residual resistance varies as the square of the speed up to 11 knots, as the cube at 12½ to 13 knots, as the fourth power about 14½ knots, and at a higher rate than the fifth power at 18 knots. Then the index begins to fall, reaching the square at 24 knots, and falling still lower at higher speeds.

It will be seen, therefore, that when this small vessel has been driven up to 24 or 25 knots by a large relative expenditure of power, further increments of speed are obtained with less proportionate additions to the power.

Passing from the destroyer to the cruiser of similar form but of 14,100 tons, and once more applying the scale of comparison, it will be seen that to 25 knots in the destroyer corresponds a speed of 47½ knots in the large vessel. In other words, the cruiser would not reach the condition where further increments of speed are obtained with comparatively moderate additions of power until she exceeded 47 knots, which is an impossible speed for such a vessel under existing conditions. The highest speeds that could be reached by the cruiser, with propelling apparatus of the lightest type yet fitted in large sea-going ships, would correspond to speeds in the destroyer for which the resistance is varying as the highest power of the speed. These are suggestive facts.

Frictional resistance, as is well known, is a most important matter in all classes of ships and at all speeds. Even in the typical destroyer this is so. At 12 knots the friction with clean-painted bottom represents 80 per cent. of the total resistance; at 16 knots, 70 per cent.; at 20 knots, a little less than 50 per cent.; and at 30 knots, 45 per cent. If the coefficient of friction were doubled and the maximum power developed with equal efficiency, the loss of speed of fully 5 knots would result.

In the cruiser of similar form the friction represents 90 per cent. at 12 knots; 85 per cent. at 16 knots; nearly 80 per cent. at 20 knots; and over 70 per cent. at 23 knots. If the coefficient of friction were doubled at 23 knots, and the corresponding power developed with equal efficiency, the loss of speed would approximate to 4 knots.

These illustrations only confirm general experience, that clean bottoms are essential to economical propulsion and the maintenance of speed, and that frequent docking is necessary in vessels with bare iron or steel skins, which foul in a comparatively short time.

Possibilities of Further Increase in Speed.

From the facts above mentioned it is obvious that the increase in speed which has been effected is the result of many improvements, and has been accompanied by large additions to size, engine-power and cost. These facts do not discourage the "inventor," who finds a favorite field of operataion in schemes for attaining speeds of 50 to 60 knots at sea in vessels of moderate size. Sometimes the key to this remarkable advance is found in devices for reducing surface friction by the use of wonderful lubricants to be applied to the wetted surfaces of ships, or by interposing a layer of air between the skins of ships and the surrounding water, or other departures from ordinary practice. If these gentlemen would "condescend to figures," their estimates, or guesses, would be less sanguine. In many cases the proposals made would fail to produce any sensible reduction in resistance; in others it would increase resistance.

Other proposals rest upon the idea that resistance may be largely reduced by adopting novel forms, departing widely from ordinary ship shapes. Very often small-scale experiments, made in an unscientific and inaccurate manner, are adduced as proofs of the advantages claimed. In other instances mere assertion is thought sufficient. Ordinarily, no regard is had to other considerations, such as internal capacity, structural weight and strength, stability and seaworthiness. Most of these proposals do not merit serious consideration. Any which seem worth investigation can be dealt with simply and effectively by the method of model experiments. A striking example of this method will be found in the unusual form of a Parliamentary Paper (No. 313 of 1873), containing a report made by Mr. William Froude to the Admiralty. Those interested in the subject will find therein much matter of special interest in connection with the conditions attending abnormally high speeds. It must suffice now to say that ship-shaped forms are not likely to be superseded at present.

The most prolific "inventions" are those connected with supposed improvements in propellers. One constantly meets with schemes guaranteed by the proposers to give largely increased efficiency and corresponding additions to speed. Variations in the numbers and forms of screws or paddles, the use of jets of water or air expelled by special apparatus through suitable openings, the employment of explosives, imitations of the fins of fishes, and numberless other departures from established practice are constantly being proposed. As a rule, the "inventors" have no intimate knowledge of the subject they treat, which is confessedly one of great difficulty. When experiments are adduced in support of proposals, they are almost always found to be inconclusive and inaccurate. More or less mathematical demonstrations find favor with other inventors, but they are not more satisfactory than the experiments. An air of great precision commonly pervades the statements made as to possible increase in efficiency or speed. I have known cases where probable speeds with novel propellers have been estimated (or guessed) to the third place of decimals. In one such instance a trial was made with the new propeller, with the result that instead of a gain in efficiency there was a serious loss of speed. Very few of the proposals made have merit enough to be subjected to trial. None of them can possibly give the benefits claimed.

It need hardly be added that in speaking thus of so-called "inventors," there is no suggestion that improvement has reached its limit, or that further discovery is not to be made. On the contrary, in regard to the forms of ships and propellers, continuous investigation is proceeding and successive advances are being made. From the nature of the case, however, the difficulties to be surmounted increase as speeds rise; and a thorough mastery of the past history and present conditions of the problems of steamship design and propulsion is required, as a preparation for fruitful work in the nature of further advance.

It would be idle to attempt any prediction as to the characteristic features of ocean navigation sixty years hence. Radical changes may well be made within that period. Confining attention to the immediate future, it seems probable that the lines of advance which I have endeavored to indicate will remain in use. Further reductions may be anticipated in the weight of propelling apparatus and fuel in proportion to the power developed; further savings in the weight of the hulls, arising from use of

stronger materials and improved structural arrangements; improvements in form; and enlargements in dimensions. If greater draughts of water can be made possible, so much the better for carrying power and speed. For merchant vessels, commercial considerations must govern the final decision; for warships the needs of naval warfare will prevail. It is certain that scientific methods of procedure, and the use of model experiments on ships and propellers, will become of increased importance.

Already avenues for further progress are being opened. For example, the use of water-tube boilers in recent cruisers and battleships of the Royal Navy has resulted in saving one-third of the weight necessary with cylindrical boilers of the ordinary type to obtain the same power, with natural draught in the stokeholes. Differences of opinion prevail, no doubt, as to the policy of adopting particular types of water-tube boilers; but the weight of opinion is distinctly in favor of some type of water-tube boiler in association with the high steam-pressures now in use. Greater safety, quicker steam raising, and other advantages, as well as economy of weight can thus be secured. Some types of water-tube boilers would give greater saving in weight than the particular type used in the foregoing comparison with cylindrical boilers.

Differences of opinion prevail also as to the upper limit of steam pressure which can with advantage be used, taking into account all the conditions in both engines and boilers. From the nature of the case, increases in pressure beyond the 160 lbs. to 180 lbs. per square inch commonly reached with cylindrical boilers, cannot have anything like the same effect upon economy of fuel as the corresponding increases have had, starting from a lower pressure. Some authorities do not favor any excess above 250 lbs. per square inch on the boilers; others would go as high as 300 lbs., and some still higher.

Passing to the engine-rooms, the use of higher steam pressures and greater rates of revolution may, and probably will, produce reductions in weight compared with power. The use of stronger materials, improved designs, better balance of the moving parts, and close attention to details, have tended in the same direction without sacrifice of strength. Necessarily, there must be a sufficient margin to secure both strength and endurance in the motive power of steamships. Existing arrangements are the outgrowth of large experience, and new departures must be carefully scrutinized.

The use of rotary engines, of which Mr. Parsons' turbo-motor is the leading example at present, gives the prospect of still further economies of weight. Mr. Parsons is disposed to think that he could about halve the weights now required for the engines, shafting, and propellers of an Atlantic liner while securing proper strength and durability. If this could be done in association with the use of water-tube boilers, it would effect a revolution in the design of this class of vessel, permitting higher speeds to be reached without exceeding the dimensions of existing ships.

It does not appear probable that with coal as fuel, water-tube boilers will surpass in economy the cylindrical boilers now in use; and skilled stoking seems essential if water-tube boilers are to be equal to the other type in rate of coal consumption. The general principle holds good that, as more perfect mechanical appliances are introduced, so more skilled and disciplined management is required in order that the full benefits may be obtained. In all steamship performances the "human factor" is of great importance, but its importance increases as the appliances

become more complex. In engine-rooms the fact has been recognized and the want met. There is no reason why it should not be similarly dealt with in the boiler-rooms.

Liquid fuel is already substituted for coal in many steamships. When sufficient quantities can be obtained it has many obvious advantages over coal, reducing greatly manual labor in embarking supplies, conveying it to the boilers, and using it as fuel. Possibly its advocates have claimed for it greater economical advantages over coal than can be supported by the results of extended experiment. Even if the saving in weight for equal evaporation is put as low as 30 per cent. of the corresponding weight of coal, it would amount to 1000 tons on a first-class Atlantic liner. This saving might be utilized in greater power and higher speed, or in increased load. There would be a substantial saving on the stoke-hole staff. At present it does not appear that adequate supplies of liquid fuel are available. Competent authorities, here and abroad, are giving attention to this question, and to the development of supplies. If the want can be met at prices justifying the use of liquid fuel there will undoubtedly be a movement in that direction.

Stronger materials for the construction of hulls are already available. They are, however, as yet but little used except for special classes of vessels. Mild steel has taken the place of iron, and effected considerable savings of weight. Alloys of steel with nickel and other metals are now made which give strength and rigidity much superior to mild steel, in association with ample ductility. For destroyers and torpedo-boats this stronger material is now largely used. It has also been adopted for certain important parts of the structures of recent ships in the Royal Navy. Of course the stronger material is more costly, but its use enables sensible economies of weight to be made It has been estimated, for example, that in an Atlantic liner of 20 knots' average speed, about 1000 tons could be saved by using nickel steel instead of mild steel. This saving would suffice to raise the average speed more than a knot, without varying the dimensions of the ship.

Alloys of aluminium have also been used for the hulls or portions of the hulls of yachts, torpedo-boats, and small vessels. Considerable savings in weight have thus been effected. On the other hand, these alloys have been seriously corroded when exposed to the action of sea water, and on that account are not likely to be extensively used. Other alloys will probably be found which will be free from this defect, and yet unite lightness with strength to a remarkable degree.

Other examples might be given of the fact that the metallurgist has by no means exhausted his resources, and that the shipbuilder may look to him for continued help in the struggle to reduce the weights of floating structures.

It is unnecessary to amplify what has already been said as to possible increase in the efficiency and types of propellers. With limited draught, as speeds increase and greater powers have to be utilized, multiple propellers will probably come into use. Mr. Parsons has shown how such problems may be dealt with; and other investigators have done valuable work in the same direction.

In view of what has happened, and is still happening, it is practically certain that the dimensions of steamships have not yet attained a maximum.

Thanks to mechanical appliances, the largest ships built, or to be built,

can be readily steered and worked. In this particular, difficulties have diminished in recent years, notwithstanding the great growth in dimensions.

Increase in length and weight favor the better maintenance of speed at sea. The tendency, therefore, will be to even greater regularity of service than at present. Quicker passages will, to some extent, diminish risks, and the chance of breakdown will be lessened if multiple propellers are used. Even now, with twin-screws, the risk of total breakdown is extremely small.

Whatever may be the size and power of steamships, there must come times at sea when they must slow down and wait for better weather. But the larger and longer the vessels, the fewer will be the occasions when this precaution need be exercised.

It must never be forgotten, that as ships grow in size, speed and cost, so the responsibilities of those in charge increase. The captain of a modern steamship needs remarkable qualities to perform his multifarious duties efficiently. The chief engineer must have great powers of organization, as well as good technical knowledge to control and utilize most advantageously the men and machinery in his charge. Apart from the ceaseless care, watchfulness and skill of officers and men, the finest ships and most perfect machinery are of little avail. The "human factor" is often forgotten, but is all-important. Let us hope that in the future, as in the past, as responsibilities increase, so will the men be found to bear them.—*Engineering.*

DESIGNS FOR THE DENVER CLASS, SHEATHED PROTECTED CRUISERS.

By Chief Constructor PHILIP HICHBORN, U. S. N., Vice-President.*

Having been invited to contribute the usual paper covering designs prepared during the past year, I take pleasure in laying before the society a brief description of the sheathed protected cruisers provided for in the last appropriations for increase of the navy, together with the general plans, a statement of the general characteristics, weights, etc.

The act of Congress approved March 3, 1899, provided for three sheathed sea-going battleships of about 13,500 tons trial displacement, at a cost for hull and machinery not to exceed $3,600,000 each; for three sheathed armored cruisers of about 12,000 tons trial displacement, at a cost for hull and machinery not to exceed $4,000,000 each; and for "six protected cruisers of about 5500 tons trial displacement, to be sheathed and coppered, and to have the highest speed compatible with good cruising qualities, great radius of action, and to carry the most powerful ordnance suited to vessels of their class, and to cost, exclusive of armament, not exceeding $1,141,800 each."

The act further provided that "in no case shall a contract be made for the construction of the hull of any vessel authorized by this act until a contract has been made for the armor of such vessel." The limiting price for the armor of these vessels was fixed by the same act at $300 per ton, and the effort to make contracts within this limit was unsuccessful. The designs for the battleships and armored cruisers have proceeded

* Read at the seventh general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17, 1899.

slowly on this account, and will not be submitted for the Navy Department's action for some time to come. I am unable, therefore, to present these designs for this year's proceedings.

The question of armor not being involved in the case of the smaller cruisers, the designs for these vessels were completed and bids invited for their construction under the usual conditions, allowing bidders to submit proposals on the plans and specifications issued by the department, or on their own plans and specifications, based upon certain requirements outlined in the department's circular issued about August 1 for the information of shipbuilders. At the time of preparing this paper, plans and specifications are being sent out to such responsible bidders as have requested them—November 1 having been set as the date for opening bids.

The chief characteristics of the design for these cruisers were settled and approved by the department before the final preparation of the general plans. These characteristics show the vessels to be about the size of the Raleigh and Cincinnati, which, though classed as 19-knot vessels, with more than double the horse-power of the present designs, have never been able, owing to certain well-known conditions, to maintain a speed even approximating to the rated 19 knots for any length of time. The Raleigh, when with Dewey's squadron, was only able to steam, with difficulty, at a speed of 9 knots, using three-fifths of the boiler power. The coal supply of these vessels was also limited, and the coal consumption was a serious question when making passage between distant ports.

In the new designs a liberal allowance has been assigned to all the principal weights, and there has been no attempt to secure "fancy" results either on paper or on trial. They have been designed for hard service, and the offensive and defensive properties, suitable speed, durability, habitability, etc., were carefully considered in determining their characteristics. Owing to the nature of the service which they were likely to perform, independence of coaling and repair stations, as far as possible, was believed to be an important consideration.

In view of the fact that the vessels were to be sheathed and coppered, and that the machinery was to be liberally proportioned, a speed of 16½ knots, as representing the capacity of the vessel at all times, was considered sufficient, and easily places the ships in the class with our earlier vessels making 19 or 20 knots on a forced trial with clean bottoms.

The coal supply is represented by a bunker capacity of 700 tons: sufficient to give them a radius of action at full speed of nearly 2500 knots, and at the most economical rate of steaming—probably in the neighborhood of 10 knots per hour—they will be able to steam about 7000 knots without recoaling. This would cover a continuous trip from San Francisco to Manila.

Careful consideration has been given to the strength of the vessels, and the scantlings are unusually heavy. The frames are spaced 36 inches throughout the length of the vessel. The inner bottom will be 204 feet in length, divided into 29 compartments. Between the inner bottom and the protective deck there will be 67 water-tight compartments, and above the protective deck, 39, making a total of 135 compartments in the vessel. They will have three complete steel decks. There will be three longitudinals on each side of the water-tight 34-inch vertical keel, in addition to the bilge stringer and side stringer. The protective deck will be water-tight and ½ inch in thickness throughout. In addition there will be 2

inches of nickel steel 8 feet in width on each slope, for a length of 105 feet in the wake of the machinery. Forward and abaft this on the slope the ½-inch plating will be doubled.

The ram bow has been entirely omitted, it being considered unnecessary for this class of vessel.

Being sheathed, the stem, stern-posts, shaft-struts and rudder will be of manganese bronze.

The wood sheathing will be of Georgia pine, fitted in a single thickness of 4 inches, secured by composition bolts tapped through the plating, and with nut and washer on the inside. The copper sheathing will be of 28- to 32-ounce material.

Over the protective deck and along the water-line a coffer-dam 27 inches in width and about 4 feet in depth will be fitted; the top of the coffer-dam being about 2½ feet above the normal or 15-foot 9-inch water-line. Fire-proofed corn-pith cellulose will be used as obturating material. This will be packed to a density of 8 pounds per cubic foot, the total capacity of the coffer-dam at this rate being about 24 tons.

The main deck will be the only one planked with wood, and this wood, together with all other wood used in the construction of the vessel, except outside sheathing and that used for special purposes, such as electric-wire mouldings, will be treated with an approved fire-proofing process before being worked into the ship. Careful attention has been given to reducing the amount of woodwork in the ship to the minimum. State-room bulkheads and the like will be of corrugated metal.

As previously stated, a liberal allowance has been made for machinery weights, the engine-room weights per indicated horse-power being about 10 per cent. heavier than is the case with the Raleigh or Detroit classes. The total machinery weight is somewhat reduced, proportionately, by the use of water-tube boilers and high pressures.

The ventilation of machinery spaces will be thorough, and not subject to the criticism to which the Raleigh and Cincinnati were exposed.

The armament of each of the vessels will consist of a main battery of ten 5-inch guns of 50 calibers length, and a secondary battery of eight 6-pounders, two 1-pounders, four Colt's automatic guns, and one 3-inch field gun. Eight of the 5-inch guns will be mounted on the gun deck in recessed ports; the forward pair having a range from directly forward to 60 degrees abaft the beam, and the second pair from 83 degrees forward to 60 degrees abaft the beam, the four after guns being similarly placed as regards stern fire. The two remaining 5-inch guns will be mounted behind shields on the main deck, one forward and one aft. Four 6-pounders will be mounted on the gun deck, two forward and two about amidships, and the other four 6-pounders will be located on the main deck. The two 1-pounder guns will be mounted aft on the gun deck, and the Colt machine guns on top of the hammock berthing amidships.

The plating around the gun ports of the gun-deck battery will be thickened up with nickel steel to 1¾ inches. The shields of the 5-inch guns on the main deck will be of 2-inch nickel steel.

The ammunition supply will be unusually large, and will include 250 rounds for each of the 5-inch guns, and 500 rounds for each of the 6-pounders. The use of smokeless powder is contemplated for all ammunition, and special appliances will be fitted for keeping the temperature of the magazines to a minimum. The nature of these appliances will de-

pend somewhat on the results of experience with the battleships now building.

Each vessel will be fitted with a distilling plant, ice-machine, refrigerating rooms, electric ammunition-hoists, winches and blowers, two searchlights, electrical signaling and other outfits. Storerooms for various purposes will be ample and commodious.

The electric generating plant will consist of 4 units, each with a rated output of 300 amperes at 80 volts.

The complete deck over the battery adds greatly to the efficiency of the design. The complement of crews assigned to each vessel is 263, including 27 marines. These can be readily accommodated. In fact, 450 men could be berthed without discomfort, and the vessels can, therefore, be used to advantage in transporting relief crews to foreign stations, or for other similar service.

Dimensions and particulars of the design, including weights and other data, including machinery, are given in an appendix to the paper, and plates are appended showing the general arrangement of the vessels.

So much has been published about the cruisers built for the Brazilian government, and purchased by us just prior to the outbreak of hostilities with Spain, that I cannot refrain from presenting a few facts—principally because the published statements have been used for the purpose of making unfavorable comparisons with our new designs. One of these publications, for instance, in a prominent scientific paper contained cuts of the vessels, with certain particulars headed, respectively, "The 3500-ton protected cruiser New Orleans" and "The proposed 3500-ton semi-protected cruiser Denver and class." It takes but a glance to discover the first gross error in this comparison, for those familiar with the facts—the New Orleans having left the New York yard a short time ago, in ordinary full-load condition, displacing over 4000 tons. Under exactly similar conditions, the Denver and class will displace only 3500 tons, and at this displacement the actual weight of ammunition carried and the actual weight of stores aboard will be greater than in the case of the New Orleans at 4000 tons. Moreover, the coal will be practically the same, for the Denver will stow and carry 700 tons readily on 3500 tons displacement, while the most that has ever been in the New Orleans bunkers, as far as is known—and certainly what was in her bunkers when displacing the 4000 tons referred to above—was less than 750 tons.

I do not pretend to criticise the design or construction of the New Orleans, but she is essentially a "show" vessel, cleverly designed to that end, but not such a design as would be found emanating from the British Admiralty or from our Navy Department. Briefly stated, she was designed purely for speed and the heaviest battery the law would allow. With her extra length of about 50 feet she will not manœuvre as well as the Denver class; with her extra draught of about 3 feet she is considerably handicapped for work in shallow harbors; with her heavy battery (of little advantage, considering the small amount of ammunition carried) she could not stand the weight of a flush upper deck, and even without it her top weights are such that, particularly without the water-line protection of cellulose provided for the Denver class, she is not nearly so well prepared to stand punishment as will be those vessels. Her powerful machinery and large battery necessitate a crew out of all proportion to the accommodations provided, and considerable objection has been filed, by those connected with the ship, in regard to the unsatisfactory

provision for officers and crew, including boat capacity for very little more than half the number. Her auxiliary appliances for lighting, heating, refrigerating, etc., were, in some cases, omitted in the original design, or were meager and unsatisfactory, and have had to be added since, with increased weight.—*Scientific American Supplement.*

CAUSES FOR THE ADOPTION OF WATER-TUBE BOILERS IN THE UNITED STATES NAVY.*

By GEORGE W. MELVILLE, Engineer-in-Chief, U. S. N., Vice-President.

It has been a number of years since I have had the honor and pleasure of addressing this society. Speaking generally, the progress and design of machinery of warships has been, during that time, along such well-developed lines, and so in accordance with the generally-accepted theories of designers, that there has been little to say. More recently, however, in order to keep pace with the times and to cope with the necessity we have always before us of securing ships that will be in nowise inferior to those built for any other nations, a change in machinery design has been made that at first glance appears radical—the general adoption of water-tube boilers for all new vessels of our navy.

Elsewhere violent diatribes have been launched against those responsible for a similar decision, and I am aware that there exists a not inconsiderable sentiment in this country against water-tube boilers. I call it a sentiment advisedly, because I believe that much of it is due to the attachment that engineers have for their old and proved friend, the cylindrical boiler.

Only a part of the opinions unfavorable to the change arises from the natural and proper conservatism of naval architects and marine engineers, but these demand answer. Flooded always with new devices, or rather by rejuvenated failures in new forms, we find a very small proportion that is even worthy of a trial, and where a new mechanical idea is tried on shipboard, so much time is spent in adapting it to naval conditions and in repairing its failures that each of us becomes naturally and properly dubious when any change is suggested. Any important change in design, even of the apparently minor fittings of ships, may involve such risk to vessel and crew as to be unjustifiable, unless the device be thoroughly tried beforehand. Many apparently good ideas have given successful results on shore only to fail dismally at sea. I think that it may be given as a general rule that no change in design should be authorized that has not already been successfully made.

Of course, a strict application of the foregoing rule would lead to stagnation. Here, however, enters the designer. His role is an important one. He has to cull the good points from previous work, and, if he be a good designer, he must also leave out the bad points. There always are some bad points, but amelioration of conditions should be the aim of naval designers. This implies that a good designer must be of vast experience and of extended observation. The larger his field of observation, the more valuable his conclusions. It is the details that count. No man can succeed as a designer of warships without the most careful attention to small things.

* Read at the seventh general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17, 1899.

The modern battleship is a monument to the greatness of the minutiæ of design. It has been gradually built up from the sailing beauties of a century ago. Steps in advance have been slow, generally speaking. We cannot advance by leaps and bounds in marine work. Here genius is hampered by such conditions as make any step in advance a great achievement. Of course, we have the case of Ericsson and the Monitor, but this was a case not only of special conditions but also of a most exceptional man. Naval architecture is a pyramid, each stone of which is supported by all of the preceding ones. The size of the stone that one man can add to the pile depends, of course, upon his ability, but more especially upon his work. By hard work and by paying attention to what is going on around him any man can add his quota, but "those who, having eyes, see not; and who, having ears, hear not," are worse than useless.

The task I have set myself to-day is no mean one. I desire to show that the decision to use nothing but water-tube boilers in our future war vessels is a step in advance, and that it is a natural step toward the evolution of the perfect fighting machine. I desire to show that it is no radical change, and that it does not involve the use of anything but a tried, successful and reliable apparatus that gives us positive and great advantages over the character of boilers heretofore generally used. I desire not to minimize the disadvantages following this change, but to show that these disadvantages are not only not insurmountable, but, for warships, they have already been overcome.

In the first place, I want to state that water-tube boilers are bad in principle. They carry the pressure inside their weakest parts, the tubes. A failure in a tube is followed by the opening of a fault, sometimes to a dangerous degree. In a fire-tubular boiler, on the contrary, the pressure would continue to close a split tube. It is true that a failure of a boiler tube generally comes from pitting, where fire-tubular boilers generally have such a great advantage, as in cases of split tubes. Yet failure of tubes is the most common defect in all boilers, and a proper design would place the pressure on the outside of the tube. Water-tube boilers are, from their very definition, designed from a wrong principle, not only because of the direction of application of pressure upon the tubes, but also on account of the decreased amount of water in the boiler, of the increased difficulty of observing a leak, and of the decreased value of heating surface in water-tube boilers. For this reason, as an engineer, it is with some misgivings that I state that I consider water-tube boilers tactical necessities for warships.

Builders of water-tube boilers use solid-drawn tubes almost exclusively for marine work. This, of course, decreases the danger of split tubes, but it does not change the mechanical principle. Some day, probably not in my time, we may hope to have a boiler having fire tubes and having the advantages of water-tube boilers. Such a boiler would force its way at once into all navies, just as water-tube boilers are doing at the present day.

Disbelieving, as I do, in the cardinal principles of water-tube boilers, I have sturdily opposed their adoption by our navy until now I am convinced that they must be used if we are not going to content ourselves with inferior ships to those built for other nations. Of course, during the period of development of the design of water-tube boilers, that even now continues, I have, in my official capacity, kept track of and taken

part in the world-wide experiments with their use. Water-tube boilers have advantages and I have never been blind to them. Two years ago I stated that their disadvantages had been sufficiently removed to justify their use on our warships. Now I consider that the value of their advantages has been sufficiently developed to necessitate their use if we do not wish to be left behind in naval design.

The principal thing to which I desire to call attention is the fact that all vessels are essentially compromises. Any ship must be considered in its entirety, and the advisability of a change in design of any part must be determined from its effect upon the ship as a whole. Whether or not water-tube boilers are superior to cylindrical boilers as boilers simply, if there be a beneficial effect upon the ship as a whole due to the adoption of water-tube boilers, these boilers are essential to the best design.

The necessity of compromise in ship design must be self-evident to the members of this society, who have the problem before them for solution almost daily. Taking the particular case of warships, the size of our ships is limited by their draught. We are building vessels now that are as large as any that can enter our harbors and docks, and we cannot, therefore, increase their power as fighting ships except by improvements in design. Any increase in weight allotted to one essential of the efficiency of the ship must be counterbalanced by a decrease in some other perhaps equally essential element. So far, this has most frequently been done by robbing the coal pile; an extra gun, a half-knot in speed, or an additional inch in armor protection—each mean a few tons less coal in the bunkers. I must except the more recent designs of battleships from the above general rules. The importance of coal endurance has become more and more manifest, and it has been appreciated fully in our recent designs. Incidentally, these last ships are fitted with water-tube boilers.

Water-tube boilers are considerably lighter than those of the old type, and their effect upon ship design may be given as follows: Of two ships having all other qualities identical, one fitted with cylindrical boilers and the other with water-tube boilers, the latter will be somewhat the smaller and handier—will have somewhat less draught, and will cost less.

Limited, as we are, in the size of our warships by their draught, I think that the foregoing shows that for a maximum of fighting efficiency we must use water-tube boilers. The designing engineers of our naval vessels are limited in weight and space. They save little or nothing in space perhaps, but they save greatly in weight if they adopt water-tube boilers. If these can be successfully operated on shipboard, they must be used because of their decreased weight. The foregoing is entirely apart from any consideration of the relative merits of water-tube and fire-tubular boilers, but it is conditional upon the possibility of the successful operation of water-tube boilers.

Before considering claimed advantages and disadvantages of water-tube boilers, I desire to give a few historical facts, most of them already well known to the members of this society.

The old Martin boiler was the first water-tube boiler ever used in any naval vessel. We had good success with these boilers, but they died out of use with the introduction of high-pressure multiple-expansion engines and the consequent cylindrical boilers.

For years none but water-tube boilers have been installed in our steam launches. These have always been attended by unskilled labor, and yet the results have been very satisfactory. Some accidents have occurred, but they have been very few, probably no greater in number than if fire-

tubular boilers had been used, and it is to be noted that the results of a boiler explosion would probably have been worse in almost every case if the failure had occurred in a fire-tubular boiler.

Torpedo-boats and destroyers in our navy have always, since the time of the Cushing, been equipped with water-tube boilers of various types. Small bent-tube boilers have generally been used. There have been some cases of sad accidents in the fire-rooms, generally due to carelessness in manufacture, and particularly in tube-setting, but not to defective design. The boilers have proved to be quite as reliable as the extremely light engines of these boats. With the small amount of skilled attention it is possible to give torpedo-boats, and considering the character of service demanded of these small craft, I think that no engineer will to-day question that the use of light water-tube boilers, with the higher speeds possible as a result, adds to their efficiency and security. I think even Herr Schichau has come to be of this opinion.

The first large installation of water-tube boilers in our navy was on the Monterey. Indeed, at the time, this was the largest installation of water-tube boilers in any navy. In this monitor, as you all know, there are four round Ward water-tube boilers, with two cylindrical single-ended fire-tubular boilers. The water-tube boilers have been satisfactory. It is worthy of note that there has been very little difficulty experienced in maintaining a steady water level, although the boilers have a very small amount of contained water. Tubes have failed by pitting several times, though never with any danger to the firemen. The water-tube boilers have been twice retubed by the ship's force without laying the ship up at any navy yard. On one occasion, probably with a view to thoroughly testing the water-tube boilers, or to satisfy the unholy desires of some person decrying water-tube boilers, the ship made a voyage of about 8000 knots, largely under forced draught, and, whenever possible, with all boilers in use. There was no resultant injury to the water-tube boilers, which performed well throughout the trial. The combustion chambers of the cylindrical boilers came out of the trial badly bulged.

The Yarrow boilers of the Nashville have operated fairly successfully, though they cannot be said to be completely satisfactory on account of the amount of trouble given by bulging of drums and by leaky tubes.

The first set of copper tubes has been replaced by others of steel to considerable advantage. I believe that the latest designs of this type of boiler provide for the use of slightly curved tubes next the fire. This ought to be advantageous.

The Marietta's trip around South America at the beginning of the war with Spain, was quite as successful as was that of the Oregon. The first ship is fitted with Babcock & Wilcox boilers, the second with cylindrical boilers. No repairs were required to either set of boilers after the completion of the trip.

The Annapolis is also equipped with Babcock & Wilcox boilers, and here, as on the Marietta, these boilers have been thoroughly successful. Indeed, a former chief engineer of the Annapolis has stated to me that the boilers of that ship were easier to manage in use and easier to maintain in a state of high efficiency than are cylindrical boilers.

The Chicago has several Babcock & Wilcox boilers, and these have so far worked in a thoroughly satisfactory manner, no failure being reported under any circumstances.

The foregoing represents the tried installations of water-tube boilers in ships larger than torpedo-boats and destroyers in the United States

Navy. Babcock & Wilcox boilers of the shore or stationary type were installed in the old monitors Canonicus, Mahopac and Manhattan, the old rectangular boilers being entirely worn out and it being deemed advisable to fit these old boats for whatever service they could do. The change was commenced at the beginning of the Spanish war. Before its close the change was complete and a somewhat greater speed was attained than with the original boilers. This change was made without injuring the decks of the monitors. The old boilers were cut up and passed out through the smokestack, down which the parts of the new boilers were passed, the latter being assembled in the engine-room space. This is an instance where none but water-tube boilers could have been used, and where every facility of repair and installation was of enormous advantage. For naval vessels with their protective decks the facility with which water-tube boilers can be removed or completely renewed without disturbing the decks may, of itself, justify us in adopting water-tube boilers.

There are building and repairing several other ships of our navy to be fitted with partial or complete outfits of water-tube boilers. These include the Alert, Atlanta, Cincinnati, Wyoming (Babcock & Wilcox), Maine and Connecticut (Niclausse), Missouri, Wisconsin and Arkansas (Thornycroft), and Florida (modified Normand).

The foregoing gives the installation of water-tube boilers in our navy from which data has been obtained. So far as tried the boilers have invariably been easy of operation, though I have found more skill required to obtain the best results from these boilers than would have been necessary if cylindrical boilers had been used. Particular attention has been given in all cases to the feed arrangements. Water-tube boilers must have ample feed pumps, and the regulation of the feed must be easy. At first the heating surface of water-tube boilers was made 3 square feet per horse-power against 2 square feet necessary with cylindrical boilers. This figure has been gradually reduced until now we are down to 2.4 square feet of heating surface per horse-power, about as low as I think it is yet safe to go with water-tube boilers.

The economical results from water-tube boilers were at first not particularly good. At present we get quite as good results from water-tube boilers of the latest design as from the best cylindrical boilers. The ratio of heating surface to grate surface has been kept up to at least 40, although we do not yet feel warranted in allowing as small grate surfaces in water-tube boilers as in cylindrical boilers. Water-tube boilers lose in efficiency when forced, especially those of the straight-tube type. Of course, this is not of very great moment to us in a naval vessel which is under forced draught only at maximum speed, but it is nevertheless a disadvantage.

The following table shows the relative economy of cylindrical and water-tube boilers.

	Annapolis.	Marietta.	Newport.	Princeton.	Vicksburg.	Wheeling.
Type and number of boilers.....	(2 B. & W.)		(2 single-ended cylindrical).			
Displacement, tons	1000	1000	1000	1000	1000	1000
Knots per ton of coal at most economical speed.....	26.38	22.27	18	19.6	21.25	16.6
Number of screws.....	1	2	1	1	1	2
Grate surface, sq. ft.....	98	94	78	78	78	60
Heating surface, sq. ft.....	3920	3664	2524	2524	2524	2508

The increased grate surface we have required with water-tube boilers will be a positive advantage to our ships' steaming qualities. I consider that sustained sea speed depends largely upon the grate surface. Heating surface, of course, must be provided, but I should prefer an excess of grate surface to an exceedingly high ratio of heating surface to grate.

Up to this time we have had no trouble from salt water or grease in water-tube boilers. Indeed, we could hardly be more troubled by salt water with this type of boiler than we have been with cylindrical boilers. We suffered severely in our short war with Spain from dropped furnaces in cylindrical boilers. I do not think that a properly designed water-tube boiler will give more trouble from the use of impure feed water, such as sometimes we must have at sea, than any other boiler. I do not think tubes more liable than furnaces to fail from a deposit of scale. In any event, the evaporating plants of all our ships are being made adequate to give fresh feed water. The only danger of salt water in the future should come from leaky condensers.

Glancing abroad for a moment, we find every modern naval power, from England to Japan, committed to the use of water-tube boilers on the largest scale. Each of these countries has had its experience, and each has decided not only that water-tube boilers can be worked, but also that they work well and that they must be used in naval vessels.

I will give a few observations on the working of various types of water-tube boilers abroad. The result of a first glance would seem to be that anything would do to make steam, from Watt's tea-kettle to the most complicated of modern steam generators. I know of one French boiler (you know what ingenious mechanics the French are) composed equally of water and fire tubes. The tubes were concentric and the distance between them but one millimeter. Of course the amount of water is very small—so small as to put this boiler in the class called by their originators "inexplosible." This boiler was tried at the works of the maker with good results. It was next tried in a torpedo-boat with equally remarkable results—7 men killed, I believe.

We have read of explosions, however, of really well-designed water-tube boilers. Generally it is found that a tube had failed and that the furnace door was open—the results, more or less fatal burns to all in the fire-room. We hear of all the failures but the successes are never mentioned. It is not difficult to foresee the failure of a boiler plant designed to furnish 120,000 pounds of steam per hour but regularly required to furnish 160,000 pounds per hour. If nothing else fails, the feed pumps will not do the work and the tubes will, of course, be burnt out. This would happen with any type of boiler.

You see, I harp on the failures, for I find I can glean the most information from them. Many of the failures have come from the use of boilers that were inaccessible for cleaning and repairs; others from faulty design; others from poor workmanship; others, again, from neglect. Water-tube boilers require skilled attendance. Other boilers have failed from poor material; others from failure of the feed pumps; but there is not one, so far as I know, that can properly be said to have failed purely as a result of being a water-tube boiler. Failures may come from misusing water-tube boilers, but not from using them. I consider that the experience of the last ten years or more in our own and in foreign navies justifies me in stating that water-tube boilers, when proper precautions are used, can be successfully adopted for the steam generating plant of ocean-going vessels. They are necessities to the best design of warships.

I would naturally come now to a discussion of the claims of the adherents and opponents of water-tube boilers. You have all heard these arguments and it seems almost useless to go over them. I shall simply state what I believe to be the advantages and disadvantages of water-tube boilers compared with cylindrical boilers.

ADVANTAGES.	DISADVANTAGES.
Less weight of water.	Greater danger from failure of tubes.
Quicker steamers.	Better feed arrangements necessary.
Quicker response to change in amount of steam required.	Greater skill required in management.
Greater freedom of expansion.	Units too small.
Higher cruising speed.	Greater grate surface and heating surface required.
More perfect circulation.	Less reserve in form of water in boiler.
Adaptability to high pressures.	Large number of parts.
Smaller steam pipes and fittings.	Tubes difficult of access.
Greater ease of repair.	Large number of joints.
Greater ease of installation.	More danger of priming.
Greater elasticity of design.	
Less danger from explosion.	

A saving in space has been claimed for water-tube boilers, but I do not find this claim sound when account is taken of the increase in grate and heating surface necessary in water-tube boilers to insure satisfactory working, and because of small units the space for accessibility is increased rather than diminished.

The fact that water-tube boilers raise steam quickly is of the greatest advantage. I have stated elsewhere that I consider the battle of Santiago to have developed the necessity of the use of water-tube boilers whether it taught us anything else or not. It would have been of the greatest advantage to have had, during the blockade of Santiago, boilers capable of raising steam in less than half an hour. Coal need not have been used to keep all the boilers under steam all the time. The Massachusetts might have shared in the glories of the fight if she had been fitted with water-tube boilers. The Indiana would have kept up with the Oregon and the Texas. The New York would have developed at least three knots more speed and the navy would have been spared a controversy. I think the Colon would not have gotten as far away as she did. But we did not have the water-tube boilers.

The higher pressures possible with water-tube boilers give us smaller and safer steam pipes and better valves. It decreases the size of the fittings and the difficulty of tracing the labyrinth of a ship's piping. It increases the efficiency of the engines. The introduction of compound engines forced us to use cylindrical boilers. In the same way the use of quadruple expansion engines necessitates, for economy, the use of water-tube boilers.

But the quick steam-raiser is, because of that very fact, not so safe as its predecessor. Of course, nothing on a man-of-war is very safe in war time, but we want things as safe as possible, and the boilers are the keys to the situation in the modern battleship. I think that safety in handling water-tube boilers may be assured by using skill in the fire-rooms. I have more than ten years' successful experience with water-tube boilers on which to found this opinion, and I submit that the boilers, placed as they are behind the heaviest armor and below the thick protective deck, are, at the worst, the safest apparatus on a battleship. If we can make them work well, we would do wrong to refuse to use water-tube boilers on our ships.

For merchant and for yacht practice it is a different question. I was recently asked what boilers to use on a large steam yacht. I recommended cylindrical boilers. For merchant work the boilers are always

in use developing a fixed power. Weight is not there so important as in warships, and I think it is at best a moot question whether cylindrical boilers are not still the best that can be fitted in ocean-going merchantmen. In some cases where there are short trips and the opportunities for repair must be gotten during the very short lay-ups at the end of the route, the quick steam-raising qualities of water-tube boilers, with their freedom of expansion, enable blowing down the boiler immediately on arrival in port and still having steam at an hour's notice on all boilers. Such cases as this seem to me to demand water-tube boilers.

As to the type of boiler to be used, there are as many to choose from as there are fleas on a dog. Some one has said that a certain amount of fleas keep a dog from brooding over being a dog. So the number of varieties we have to choose from may be a good thing for all.

I have always opposed the use of boilers containing screw joints in contact with the fire, and have attempted to secure boilers having no cast metal in the pressure parts. Cast-steel is not yet good enough to put between 300 pounds of steam and our firemen. I believe in straight-tube boilers as being easier of examination and repair than bent-tube boilers. I believe in large-tube boilers for the same reason and because the tubes are thicker and have more margin for corrosion. I believe in boilers having as few joints as possible. Water-tube boilers must have freedom of expansion of the various parts, and the simpler the boiler the better. It should not be necessary to introduce reducing valves between the boilers and the engines to secure a steady steam pressure at the latter, nor should it be necessary to have automatic feed arrangements to insure steady water level in the boilers. To be successful a boiler must be easy of repair. Lightness is a natural attribute of all water-tube boilers, but it is not wise to go too far in this direction. The ratio of grate surface to fire surface occupied for the complete boiler plant must be as large as possible. The units should be large, the grates short and not too wide. The passage of gases through the tubes should be sufficiently long to insure economy. These gases should be well mixed before entering the spaces between the tubes for the same reason and to prevent smoke. The circulation of the water in the boiler must be free. Tubes should not be too long and the fire-rooms must always be sufficiently wide to provide for free withdrawal.

The foregoing is what we want. We have most of the above desiderata in several well-known types of boilers, and ultimately we shall discover the value of each of the foregoing points, and then it will be possible to differentiate between the various types more perfectly than we now can.

In the meantime, all that I have to say is that the use of water-tube boilers has been definitely decided upon for our naval vessels, because water-tube boilers give tactical advantages of great moment, and because, with care in the selection, manufacture and management of water-tube boilers, other disadvantages may be neutralized.—*Scientific American Supplement.*

REPORT OF THE CHIEF OF THE BUREAU OF ORDNANCE.*

According to the annual report of the Chief of the Bureau of Ordnance, of the total of 939 main-battery guns authorized, 756 have been com-

* Extract from the annual report of Rear-Admiral O'Neil.

pleted and 751 assigned, while 13 are partially completed, and the forgings for 174 have been ordered. None of the 12-inch, 40-caliber guns are yet ready. The forgings have been ordered for the 5-inch 50-caliber guns, but none of this type are yet being made.

The new model guns have enlarged powder chambers and are of the following lengths, viz., 10 and 12-inch, 40-calibers; 8-inch, 45-calibers; 3, 4, 5 and 6-inch, 50-calibers. The first of the new 4-inch guns with its mount has been completed and tested. The gun exhibited excellent ballistic properties, a muzzle velocity of 2991 foot-seconds having been recorded within the limits of chamber pressure for which the gun was designed (viz., 17 tons per square inch), using navy smokeless powder not especially manufactured for this type of gun. It is expected that still better results will be obtained when the exact size of grain is determined for the powder. The first of the new 6-inch guns, with its mount, is nearly completed, and will soon be tested, and the first of the new 12-inch guns is assembled and in an advanced state. Two 8-inch nickel steel guns have been assembled. One of them is to be fitted with a quick-firing breech mechanism of new type, designed by Lieut. F. J. Haeseler, U. S. N., a similar mechanism fitted to a 4-inch gun having given good results. The satisfactory performance of the new 4-inch gun, which is made on the same design as regards chamber as the larger calibers, justifies the bureau in anticipating equally good results from the latter. The gun steel delivered by the manufacturers has been of excellent quality, and but very few forgings have been rejected. The process of gun manufacture is rapidly and accurately carried on at the naval gun factory, due to excellent machinery, new and good mechanical devices, and to the intelligence and skill of the operatives.

The new guns will be fitted with the "Welin screw" or breech-plug, which gives a proportionally larger threaded area than the plugs now in service, and therefore admits of a shorter and lighter plug, which is a matter of considerable importance, especially in the larger calibers. A new type of breech mechanism has been adopted for the 6-inch and 5-inch rapid-fire guns of 50 calibers which possesses several admirable features. It has great power to unlock, has a combination electric and percussion firing attachment, and an automatic ejection of the primer. These guns will not require brass cartridge cases.

The work on gun mounts has progressed simultaneously with the guns. The turret mounts of the four new harbor-defense monitors will have the same general characteristics as those for the Alabama and Maine class, but the construction has been improved in several important details. The first mount is well under way. A new type of 6-inch mount for the 6-inch gun of 50 calibers has been designed, and is nearly completed and will soon be tested. A new type of mount for the 4-inch 50-caliber gun has been designed, manufactured and tested with satisfactory results.

A 14-pounder (3-inch) rapid-fire gun is completed, and the mount nearly ready, and both will soon be tested. This is a new type of gun so far as the navy is concerned, and is intended for part of the armament of the new "destroyers," and probably will form an important part of the secondary battery of future battleships and large cruisers. It is designed for 3000 foot-seconds muzzle velocity, and, therefore, should have great range and a flat trajectory. Its remaining velocity at 3000 yards should be 1400 foot-seconds, which would give it a penetrating power of 1.52 inches of Harveyized steel, or 1.22 inches of Krupp armor at that

distance, rendering it a destructive weapon against the unarmored portions and exposed gun positions of an enemy's vessels.

All the new guns are being fitted for a telescope sight, and for a bar sight for day and night use, designed by Lieut. H. D. Tisdale, U. S. N., an officer on duty at the gun factory, who has also been largely instrumental in improving the pedestal mounts above referred to.

New and improved ammunition hoists have been designed and manufactured for the 8-inch turrets of the New York and Indiana, and similar hoists are in an advanced state for the Oregon, Olympia and Massachusetts. Hydro-pneumatic rammers have been manufactured and installed on board the Oregon, Massachusetts and Indiana in place of the former hydraulic rammers, which were constantly giving out, and others are now in an advanced state for the older monitors, which are now supplied with hydraulic rammers. All the later ships are to be supplied with the chain rammer, which can be operated by hand or electric power.

A new type of combination primer has been developed at the torpedo station, and promises to give excellent results. The question of a means of reducing the temperature of magazines on board ship by connecting them with the refrigerating plant is now under consideration, and preliminary steps have been taken to introduce such a feature on the battleships now being built. Special attention is being given, in connection with the Bureau of Construction and Repair, to providing good means of ventilation for turrets, a matter that the recent war showed was most important.

Owing to the number of purchased vessels added to the navy during the recent war, the supply of reserve guns has been considerably depleted, and a further appropriation for them is asked. At the naval gun factory, at the Washington Navy Yard, 113 enlisted men have been under instruction and 80 at the torpedo station.

The batteries for the Kearsarge and Kentucky, with their accessories, have been completed, with the exception of the 5-inch guns and top carriages, which will be completed by the time the vessels are finished. The 13-inch guns of the Alabama and the turret fittings have been completed. The 6-inch guns are completed and their mounts will be ready in about two months. The 13-inch guns and mounts for the Wisconsin are completed. The 6-inch guns are completed and their mounts will be ready in about three months. The 13-inch guns and mounts for the Illinois are completed. The 6-inch guns and mounts will be completed in about four months. The entire ordnance outfit for all the above vessels will be ready in advance of the completion of the ships. A battery has been completed for the training-ship Chesapeake.

All the above vessels will receive entire outfits of smokeless powder.

The guns for the battleships Maine, Ohio and Missouri and the four harbor-defense monitors are under way, and they will be completed far in advance of the vessels, as will the armament of the Denver class. The launching-tubes for all new destroyers and torpedo-boats are completed, and their batteries will be ready in time.

The main battery of the battleships Maine, Ohio and Missouri will consist of four 12-inch guns of 40 calibers, and of sixteen 6-inch rapid-fire guns of 50 calibers.

The new monitors Arkansas, Florida, Wyoming and Connecticut will each carry two 12-inch 40-caliber guns and four 4-inch 50-caliber guns with shields. The six cruisers of the Denver class will each carry ten 5-inch guns of 50 calibers.

The development of the 12-inch gun has been so great that its adoption for recent vessels, rather than the 13-inch gun on the older vessels, became a logical sequence. It has a projectile of but 850 pounds weight as against 1100 pounds for the 13-inch gun, but the muzzle velocity will be not less than 2800 foot-seconds against 2300 foot-seconds. The muzzle energy will therefore be 46,186 foot-tons as against 40,404 foot-tons for the 13-inch gun; penetrating power at 3000 yards 17.92 inches of Harveyized nickel steel armor as against 15.91 inches. The racking and battering effect will be less. The new 12-inch gun will readily perforate any armor afloat or likely to be put afloat, and the bureau considers it a more suitable weapon for the new battleships than a gun of larger caliber.

The 6-inch rapid-fire 50-caliber gun for the new vessels will have a muzzle velocity exceeding 2900 foot-seconds, with a muzzle energy of not less than 5838 foot-tons. At 3000 yards they will have the power to penetrate Harveyized nickel steel armor of 5.3 inches in thickness, and they have a proving-ground record of ten rounds per minute.

The new 5-inch gun for the Denver class and the 4-inch for the monitors will be of 50 calibers and capable of developing a muzzle velocity of 3000 foot-seconds.

There are in service a considerable number of 6-millimeter automatic Colt guns, which, in general, have given good satisfaction. When they have failed it has almost invariably been due to neglect of some necessary precaution. Great accuracy is required in filling the belts; the parts move with great rapidity and the barrel becomes very hot after a short time, rendering it difficult to adjust any derangement which may occur. The bureau has ordered a 0.30-caliber Colt automatic to handle the army cartridge, for test and experiment. A 0.30-caliber Gatling, to handle the army cartridge, has also been ordered. The bureau is of the opinion that it will be found expedient to supply each vessel with a number of automatic guns of small-arm caliber, according to her class, and one hand-working gun. Under such conditions vessels will be in this respect well equipped for any service. A new type of fully automatic 3-pounder gun has been tried with promising results. Such a gun has a rate of possible fire of 70 per minute, as compared with 40 for the semi-automatic gun. It also has the advantage of having four shots in immediate readiness. This device can also be attached to the 6-pounder semi-automatic gun, and the bureau is having one so fitted for experiment.

The question of the supply of armor stands as follows: The contracts for the Kearsarge and Kentucky have been completed. Armor is now being manufactured for the battleships Alabama, Illinois and Wisconsin. There remains to be delivered for these vessels, 832 tons for the Alabama, 1255 tons for the Illinois, and 394 tons for the Wisconsin, a total of 2481 tons. Of this amount about 1000 tons will probably be delivered during the next six weeks. The armor contracts for these vessels will probably be completed by January 1, 1900, or thereabouts.

The delay in contracting for the armor for these vessels was due to the fact that Congress had limited the price.

By January, 1900, the contracts should be made for the armor for the three vessels of the Maine class. Such armor as can probably be procured for $400 per ton is not the best armor that can be made, and hence is not suitable for the vessels in question. The bureau urges that the matter be laid before Congress as soon as it assembles.

The question of a government armor factory should have no bearing

upon the supply of armor for the Maine, Ohio and Missouri, as it would under any circumstances be impracticable to obtain it from such a source in time to complete the vessels above referred to. No detriment or inconvenience to the government or its interests has been caused by this delay; but, as previously stated, armor for the above vessels should be contracted for by January, 1900. If, after a further presentation of the case, Congress decides to adhere to the present limitation, the department will probably be obliged to procure armor similar to that heretofore and now being used, but it will have the consciousness of having performed its duty in the matter and will be free from further responsibility. It is quite evident that the building of armored ships of war must soon be discontinued by this government, until the vexed questions of the source of supply and cost of armor are disposed of.

Notwithstanding the improvements, the facilities of the gun factory are inadequate to meet the pressing demands of the service, and it is imperative that further extensions and additions be made.

During the year, 161 guns of various calibers have been proved. No weakness or defect has been observed in any of them, though usually subjected to pressures much higher than obtained in service. Numerous tests of armor plate for vessels now building have been made. Armor-piercing and common shell, representing numerous lots of all calibers, have been tested, with, in most instances, satisfactory results.

The bureau discontinued the purchase of brown powder as soon as the late war with Spain was over, and having a good supply on hand, which can gradually be used up for target practice, directed the powder manufacturers to give their attention entirely to the production of smokeless powder of navy standard, known as pyro-cellulose. It is most gratifying to the bureau to be able to report that thus far no unfavorable qualities have been detected in this powder when properly made. Its ballistic properties and keeping qualities appear to be excellent and to remain unimpaired even when subjected to excessive temperatures of heat and cold and to extreme degrees of moisture. No dangerous pressures are recorded, nor have any of abnormal character been observed in well-made powder of this kind. The question as to the best mode of ignition is now receiving considerable attention. The bureau has decided, as a precaution to be observed for a year or two, to fix rather small charges; this not only for the purpose of observation and safety, but that the guns may not suffer unduly from erosion, though the latter thus far is almost an unknown condition, which seems to be one of the very good qualities of the navy smokeless power, as compared with cordite and other powders containing nitroglycerin.

The uniformity of navy smokeless powder depends largely upon the rate and thoroughness of drying and upon the amount of solvent remaining in it when used. The specifications are, however, very explicit in this respect, and are fully understood by the manufacturers. The drying requires usually from four to six weeks, and where large quantities are turned out daily, the question of drying becomes a serious one, particularly so on account of the risk in case of fire, as a large amount of capital is kept in a precarious state pending the acceptance of the manufactured article. It is not unlikely that by processes other than those now followed, quicker drying can be effected.—*Scientific American Supplement.*

A NEW TYPE OF BATTLESHIPS—THE FRENCH HENRI QUATRE.

It is curious that while the launching of the Henri IV in France has been attended with a good deal of trumpet-blowing, prophecy, and what not, the affair has produced next to no notice in this country, and such little attention as it has received has been confined to irrelevant remarks to the effect that the ship has broken no record in construction. Yet—for the present, at any rate—the Henri IV marks an epoch in French naval construction of little less importance than the launch of La Gloire, the first sea-going ironclad. The Henri IV is avowedly an experimental ship, and one of which great things are expected, and which, if as successful as anticipated, will be adopted as the standard model for finality in battleship construction. If she is a success, other ships may be constructed larger and heavier, but they will be identical in type. Herein is surely a matter of some moment to us, even apart from the ordinary interest that attaches to such a revolutionary design. For, mixture of the circular Russian ironclad Vice-Admiral Popoff, of the Inflexible, and of the modern Bouvines as the Henri Quatre is, she is none the less, for the French, an absolute revolution. She marks, amongst other things, the abandonment of the sky-scraping superstructure to which the French have so long adhered; she marks also a "throw-back" in design, a throw-back to the later seventies.

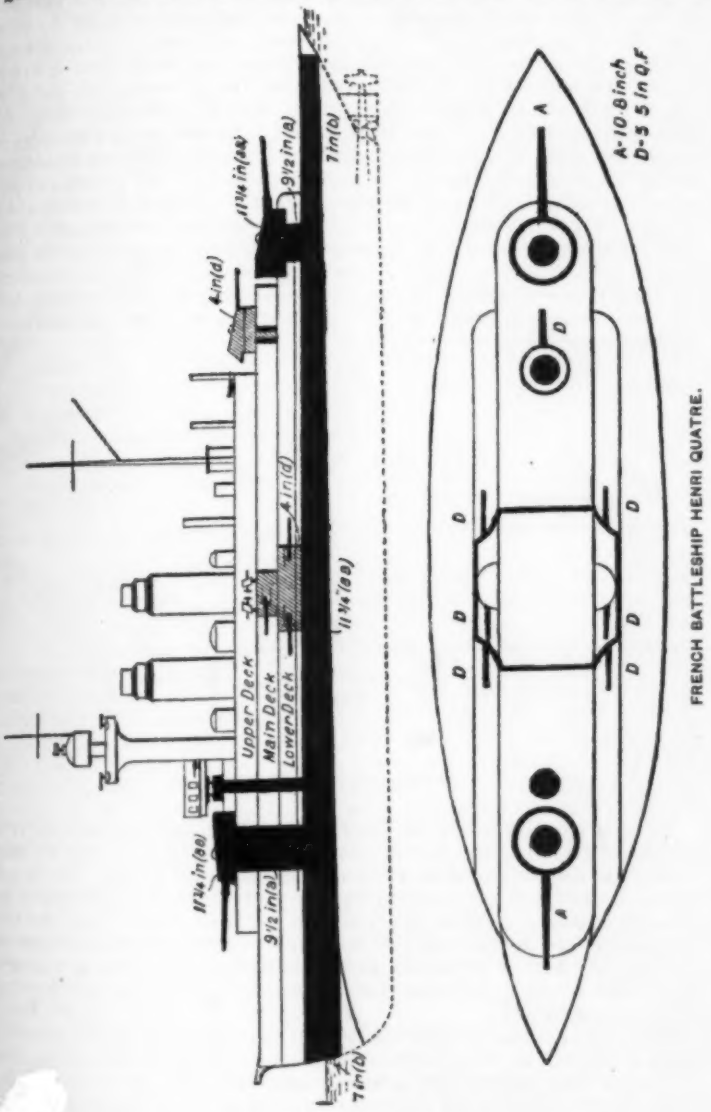
Let us first consider the ship's measurements, the proportions in which finality is chiefly sought, comparing her with the ships she mostly resembles in appearance, and with the Charlemagne type that preceded her:

	Henri IV.	Inflexible.	Popoff.	Bouvines.	Charlemagne.
Date	1899	1876	1875	1891	1895
Displacement, tons	9000	11,800	3550	6610	11,260
Length in feet	350	320	120	292	361
Beam, feet	73	75	120	50	67
Draught, feet max.	23	29	13½	24½	28

The Bouvines, it should be remembered, is 5 feet broader than her immediate predecessor, the Valmy, of the same general type. Now the proportions of length to breadth in these compared ships are, roughly: (Circular) Popoff, 1:1; Inflexible, 4.3:1; Henri IV, 4.8:1; Bouvines, 5:1; Charlemagne, 5.7:1.

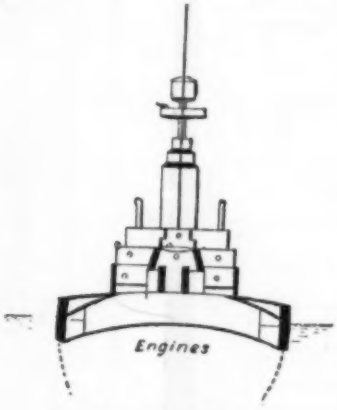
The average proportion of length to beam for French battleships has been about that of the Charlemagne hitherto, the Bouvines being the first departure. As most of our readers are aware, the Valmy, from which the Bouvines is derived, is a low freeboard ship, completely belted, with a big gun forward, another aft, and a superstructure between. This type did not behave well at sea, so the Bouvines and Trehouart were built with raised forecastles. In this the Henri Quatre directly follows the Bouvines. Where she differs from the Bouvines, and from every other modern ship, is in the fashion of her hull. Like the Bouvines, she has a high forecastle; like the Bouvines, she carries one big gun on this, and the other at a lower altitude aft, but here resemblance ceases. Directly the sides leave the immediate bow they no longer follow the water-line, but a straight line inboard, the idea of twenty years or more ago, when the Inflexible was built, and abandoned with the Austro-Hungarian Kronprinz Rudolf, launched in 1887. Experience has taught us that these ships will take water on the deck, and that this water is a

nuisance in every way. The French claim as a feature of the Henri Quatre that, having her decks thus open, she has nothing to fear in



from water finding its way on to the lower deck. "It can run where it chooses."

However, 1899 is not 1876, and for 1876 brought up to date there is more than this to be said. To begin with, the Henri IV is so built that the lower deck slopes away aft at an angle sufficient to make the water run fast in that direction. There are holes aft, too, to carry it away. Further, the armor deck is a different thing now from what it was in those days, and the Henri IV is really that "ship upon a raft body" of which we heard so much in past years. She is, to begin with, armor-belted, except in the extreme stern, where a bulkhead takes the place of armor, following the sharp V shape of the stern; this V being an addition to her length that minimizes her paper breadth. To all intents and purposes the hull is only some 325 feet long, and the stern is merely a projection. The thickness of the belt—which is Harveyized—varies from 11¾ inches to 7 inches—the "war-game notation" is given in the plan. This is reinforced by a curved armor deck, the deck itself is also armored, the total thickness being 3 inches. Below the belt is another armor deck of 1 inch, specially hardened steel. In addition there is, of course, coal bunkers' protection.



HENRI QUATRE—END VIEW.

The big gun turrets are on the French system, with 9½-inch supports and bases and 11¾-inch hoods. Each carries a 10.8 gun, with an initial velocity of 2625 foot-seconds and an energy of about 22,750. This is only about two-thirds of our ordinary 12-inch wire. Still, it is sufficient to get through nearly any armor afloat at 1000 yards or more. Over the after big gun a 5.5-inch quick-firer is mounted. In the battery six more are carried. All have a protection of 4-inch Harvey, and hence are open to shot from a 6-inch quick-fire gun. However, this 4-inch will keep out shell from that piece.

It is not yet clear whether the rest of the hull between the lower and main decks will be armored; the presumption is that it will not be, since a 9000-ton ship could hardly, perhaps, carry it in addition to all the other armor. Other details the plans and illustrations make apparent.

Now, the most casual comparison of the ship with previous French models must render obvious the increased stability of the Henri IV. There are no enormous weights projecting amidships, no huge super-

structures the destruction of which must affect stability. She is built not to capsize. At the same time the vessel offers some weak points; the pillars on which the big guns stand are a sorry substitute for our huge armored bases, and persistent shell-fire around these should leave a somewhat top-heavy concern, that forward, at least, might well capsize with the stress of firing. As for the battery, one big shell or a number of 6-inch shot would settle the six central quick-firing guns; the weak point of a concentrated armament is accentuated here by the thin redoubt and its comparative narrowness. No doubt screens will be fitted inside it, still a single big shell is pretty certain to "do up" the whole concern. When all is said and done, however, the weakness of the Henri IV is, perhaps, rather on paper than in fact. At sea she is more likely to do better than worse than she looks on paper, and compared to the generality of French ships she is an infinitely smaller target.

In armament she carries, in addition to the pieces named, twelve 3-pounder quick-firers, and probably a couple of submerged torpedo-tubes. Her exact torpedo armament seems as yet in some doubt. Comparing her armament with some other vessels of about her tonnage, we find that it is by no means excessive; indeed, it is the French who say that English ships carry too many guns.

The following are the comparisons:

	Henry IV.	Sissoi Veliky.	Rostislav.
Main armament	two 10.8-in. (A)	four 12-in. (A)	four 10-in. (B)
Secondary	seven 65.5-in. (D)	six 6-in. (D)	eight 6-in. (D)

These are the only modern vessels of displacements anywhere near 9000 tons.

All the Henri IV's guns are electrically worked. Her normal coal supply is 725 tons, the capacity of the bunkers is 1100. Nominally, this stands for 7500 miles at 10 knots with full bunkers. The Sissoi and Rostislav only carry 500 tons with a maximum of 800, and a nominal 2000-mile radius.

She will be fitted with Niclausse boilers. The designed horse-power is 12,000; there are three screws, and the expected speed is 17 knots. With her shape the Henri IV in anything of a sea is likely to be nearer 12 knots than 17 knots. Vessels on this model—for her shape is very akin to the Inflexible's in many ways—duck their noses tremendously in any seaway, and tons of water come upon the low decks. How much they will get in this way, the French have yet to discover.—*The Engineer.*

JAPANESE TORPEDO-BOAT DESTROYERS.

In a late issue we very briefly noted that the official trial had taken place of the fourth out of the six torpedo-boat destroyers that have been under construction during the past year by Yarrow & Co., Limited, of Poplar, for the Imperial Japanese Navy.

The Sazanami, on her three hours' official trial attained the exceptional mean speed of 31.382 knots an hour. This vessel, like the three that have preceded her from her builders' yard at Poplar—two of which have already arrived in Japan and proved themselves excellent sea boats—is 220 feet long by 20 feet 6 inches beam, and is propelled by twin screws. She is built of galvanized steel of extra strength, the longitudinal seams in her hull plating being joggled, instead of fitted with the old-fashioned

lining strips on the frames; the upper strakes having the rivet-heads projecting instead of being countersunk, so supporting the plate and helping to stiffen it.

The propelling machinery of the Sazanami consists of two sets of four-cylinder four-cranked triple-expansion engines of Messrs. Yarrow's well-known make; the high and intermediate-pressure cylinders being 20½ inches and 31½ inches diameter respectively, the two low-pressure cylinders, which are placed at the forward and after ends of the sets, are each 34 inches diameter, all having a piston stroke of 18 inches.

Steam is supplied by four water-tube boilers of the Yarrow straight-tube type. The engines, which are designed to develop 6000 indicated horse-power, are balanced on the now well-known Yarrow-Schlick-Tweedy system; their reversing being effected by direct action, and not on the so-called all-round system, the action being remarkably quick, and as proved in handling them, specially suitable for high-speed engines.

The main steam pipes of the engines are of mild steel solid drawn, and are fitted with special expansion joints to prevent any working of the ship's hull putting an undue strain upon the pipes, independent of that caused by their expansion by heat.

The coal stowage of the Sazanami is from 90 to 100 tons, sufficient to carry her at a fair speed across the Atlantic. The accommodation for officers and crew is also exceptionally good, and the lighting throughout is electric.

A fact specially noticeable in connection with the steaming of the vessel is the ample margin provided in boiler power, each boiler being able to supply 100 horse-power beyond that required to develop the engine power contracted for. This feature was specially marked on the vessel's trial, and is proved by the absence of any discoloration in either of her four funnels, the paint on which had not been renewed since the day she was launched, accounted for by the low air pressure necessary when under forced draught and the absence of any flaming.

On the official trial of the vessel, the dead load carried was 35 tons, and the mean result attained, with the engines making a mean of 392 revolutions a minute, was a mean speed of ship of 31.38 knots an hour, the air pressure in stokeholds being 1⅜ inches, and the coal consumption during the three hours' running 15½ tons.—*The Engineer.*

ARMOR FOR NEW RUSSIAN SHIPS.

We give herewith a report showing the result of an extremely important plate trial, namely, the test on supply, of the plates made by Messrs. Carnegie for the quick-firing batteries of the Russian battleship Retvizan, building at Cramp's yard, Philadelphia. It may be seen that this shows a great advance in defensive power. Any reader of Brassey's or the *Pub Annual* may see that very few foreign battleships have armor 5 inches thick in front of their quick-firing guns, and this Krupp process plate has far greater resisting power than those hitherto made. England, happily, has long covered the quick-firing guns of her principal battleships with 6-inch Harveyed, and latterly Krupp process armor. Other nations have generally contented themselves with far less protection. By the time the Retvizan and ships similarly protected are afloat, we shall need the more powerful quick-firing guns which are contemplated,

whether 7.5-inch or 8-inch. It may be seen that no projectile in this test approached perforation near enough to be able to estimate the full resisting power of this plate. The heaviest blow was that of No. 4 round, which had a striking energy of 1528 foot-tons, and by Tresidder's formula a perforation of 11.5 inches of iron, so that the factor or figure of merit of a plate which just keeps out such a blow is 2.3, that is, the plate would be equal to 2⅓ times its thickness in wrought iron; but since this blow did not approach perforation, the plate had a considerably higher figure of merit, so that it would need more favorable conditions than generally occur on service for our 6-inch guns to master it. It is to be noticed that the plate showed signs of yielding, not in front of the point of the shot, but round the circumference, so that "boring" had been completely defeated, and perforation would have to be effected by punching out a disc. This involves waste of energy in setting up the head, increased requirement of energy to get through even by punching rather than boring, and it involves the shot having the dislodged disc of plate in its way after it gets through.

Efforts are being made by all makers to give hard faces to thinner plates, but up to the present time the tendency to warp has prohibited it for plates below 4 inches in thickness, and the hardening of thin steel is a recent achievement at Sheffield, and we question if foreign makers have got further, if as far. The best thin armor is generally now that known as Krupp non-cemented, which is hard and tough, but has not the adamantine water-hardened face found in thicker plates.

On the other hand, the manufacture of really thick Krupp process plates is a work that taxes the power of manufacturers at first. Messrs. Carnegie have, we understand, so far progressed as to have a thick plate now ready for trial. The peculiarity of the Krupp process, and the circumstances—among them the clear grasp of the situation by Sir W. White—combined to provide the quick-firing guns of our armor-clads with a protection out of all proportion to that of other vessels. We hope this will be borne in mind by any powers who are inclined to test our ships, remembering that the principal fighting is done by these guns.

On September 20th, at Indian Head, the Krupp ballistic plate R. N. P. 179, representing the first group of armor for the Russian battleship Retvizan, was tested. This plate was 126¼ inches long by 91⅝ inches wide and 5 inches thick. The plate was trapezoidal in shape, with one edge beveled. It was backed in the usual manner with 12 inches of oak timbers, and two ⅝-inch skin plates. Facing the plate as mounted, the left-hand edge was the bottom of the plate with reference to the ingot, the beveled edge being on the right hand.

The first point of impact was taken near the center of the plate, at a distance of 41 inches from the bottom edge, and 61 inches from the left-hand edge. Midvale 5-inch uncapped a. p. shell, No. 91 of lot 21 made in the present year, was selected for this round. The charge of powder was 12.55 pounds, of C. S. B. 14 smokeless powder. The shell broke up on the plate, leaving a small portion of the point of the shell embedded in the plate; the rest of the shell was scattered in small pieces. The estimated penetration was 2 inches. The plate was dished ⅛ inch. The average diameter of the flaking was 12½ inches. The metal of the face of the plate was very hard, and of fine dark grey crystals, super-carbonated near the surface. The striking velocity, as measured through the screens, was 2060 foot-seconds, the required striking velocity being 2058 foot-seconds.

The same charge of powder was used in each of the succeeding rounds.

In the second round a 5-inch Wheeler-Sterling uncapped a. p. shell, No. 2295 of lot 19, was selected. This shell also was made this year. The second point of impact was taken at a distance of 29 inches from the left-hand edge of the plate, 32 inches from the center of the first point of impact, and 42 inches from the bottom of the plate. The shell broke up as in the preceding round, with the same estimated penetration and dish of plate. The average diameter of flaking was 12 inches. The striking velocity was 2086 foot-seconds.

For the third round Carpenter 5-inch uncapped a. p. shell, No. 4718 of lot 14 of the present year, was selected. This point of impact was taken at a distance of 43 inches from the bottom of the plate, 27½ inches from the center of the first point of impact, and 25 inches from the right-hand edge of the plate. The shell broke up as in the preceding rounds, the dish and penetration being the same, and the average diameter of the flaking 10½ inches. The striking velocity was 2057.

For the fourth round a Midvale 5-inch uncapped a. p. shell of lot 20 was used. The point of impact for this round was 23 inches from the top of the plate, and 49 inches from the right-hand edge. The striking velocity was 2099 foot-seconds. The estimated penetration was about 2 inches, as in the preceding rounds. The average diameter of the flaking was 14 inches. The shell broke up, as in the preceding rounds.

For the fifth round a Wheeler-Sterling uncapped a. p. shell, No. 2054 of lot 18 of the present year was selected. This point of impact was taken at 19 inches from the bottom of the plate, 41 inches from the center of the first point of impact, and 61½ inches from the left-hand edge of the plate. The shell broke up as in the preceding round, having attained the same estimated penetration of 2 inches. The plate was dished ¼ inch. The average diameter of the flaking was only about 5½ inches. The striking velocity was 2082 foot-seconds. This impact detached a large piece of the face of the plate under the first point of impact, showing more fully the fine quality of the metal. In all of these impacts the wedging action of the shell was clearly shown in the cracks round the edge of the flaking, indicating that if the velocity were sufficient to cause perforation it would be done by driving out a large piece of the plate. There were no cracks in the plate.

The weight of shell in each round was 50 pounds. The striking energies were 1471, 1508, 1466, 1527 and 1502 foot-tons.

It is hard to estimate what the ultimate resistance of this plate would be with the shell used, but it is evident that the plate would have stood a very considerable increase of velocity from that used. Admiral O'Neil expressed his opinion most decidedly that it was the best plate ever tested in this country.—*The Engineer.*

PROGRESS OF THE PARSONS STEAM TURBINE FOR MARINE PROPULSION.

A company styled the Parsons Marine Steam Turbine Company was formed late in 1897 for the purpose of taking over the rights and property of the original organization which built and tested the Turbinia.

The company has now in hand two torpedo-boat destroyers of large power and high speed, one, we understand, being for the British Gov-

ernment, and the other for Armstrong, Whitworth & Co. One, if not both, of the vessels is fitted with two separate sets of engines for the port and starboard sides respectively, and four propeller shafts. One each side the outer shaft is driven by a high pressure turbine, and the inner by a low pressure turbine, the inner shaft having also a small reversing turbine connected up. The total power available for going ahead is 10,000 I. H. P., which, on the dimensions, is calculated to give a speed of 35 knots. There is enough power available for reversing to send the boat astern at 16 knots. Condensers are fitted for each set of engines, and the air pumps are driven by small turbines, so that all reciprocating parts are got rid of, together with the probability of anndying vibrations which the usual form of pump would set up. For boiler feed steam pumps of the Weir pattern are fitted. Lubrication of the main bearings is secured by a system of forced oil circulation.

To get this amount of propulsive power upon the displacement of the regular 30-knot destroyer means, of course, a saving of weight somewhere, and in this is pointed out one of the advantages of the turbine method of propulsion. The engines are of less weight though of vastly more power than reciprocating destroyer engines, and the saving here is made use of in the needed enlargement of the boiler capacity. This amounts to about 12 per cent. in size. A gain is also expected in the steam consumption of the turbines as compared with the most economical form of the reciprocating type of engine. There is also a saving in weights of shafting and propellers. In a destroyer of 310 tons displacement it is estimated closely that the saving in machinery weights will permit of an increase of the steam-raising capacity to the extent of about 2000 square feet of boiler heating surface. It is also claimed by the inventor that on account of the absence of heavy reciprocating parts, linkage, etc., in the engines that they can be made with a larger margin of strength and capacity than reciprocating engines.

A comparative statement is made between a destroyer of 320 tons displacement equipped with express water-tube boilers and turbine engines of about 12,000 I. H. P. and a destroyer of say 300 tons displacement with express water-tube boilers and reciprocating engines of about 6000 I. H. P., as follows:

	Turbine Destroyer.	Regular Type.
Boiler-room weights with water in boiler	225,680 lbs.	174,720 lbs.
Engine-room weights with auxiliary gear and water in condensers.....	117,185 lbs.	125,440 lbs.
Weight of propellers and shafting, etc..	17,304 lbs.	22,400 lbs.
	360,169 lbs.	322,560 lbs.

Consequently the weight of machinery of the turbine destroyer figures out 30.01 pounds per indicated horse-power, and that of the ordinary type destroyer exactly 53.76 pounds per indicated horse-power. The hull of the turbine destroyer can also be made lighter, as the rotary motion of the turbine and absence of vibration make it possible to dispense with the added weights at the after end for structural strength, such as are demanded with the reciprocating form of engine.

It will be remembered that a series of observations were made by Prof. Ewing on the Turbinia when she came out, at the request of the owners. The important question of steam consumption, among others, received special attention. The indicator could not, of course, be applied to the turbine form of engine, and so the resistance of the vessel derived from tank experiments was used as a basis for computing the horse-power at

any speed up to a maximum of 32 knots. An exact record of the amount of feed, etc., used was also kept, and from the data thus secured the steam consumption for all purposes at the 31-knot speed was found to be 28 pounds per propulsive horse-power. This, on the basis of 55 per cent. of propulsive to indicated horse-power, gave a steam consumption of 14½ pounds per indicated horse-power, and the coal consumption was rather less than 2 pounds per I. H. P. per hour.

How far these expected results will be reached or surpassed in the vessels under construction remains to be seen. Recent brief telegraphic reports seemed to indicate that the preliminary trials of one of the vessels were not satisfactory, but this is no criterion. Some detail of construction or equipment which might have no bearing whatever upon the efficiency of the machinery could, reasonably, be responsible for delay or disappointment.

No doubt the success of boats of the character of those now in hand would greatly aid in a more wide-spread adoption of the turbine form of propulsion. It is claimed for this type of engine that with larger engines, such as would be needed for full-powered sea-going vessels, the conditions for the highest economy in steam with a minimum of weight, could not be more easily met. While as yet no orders for the equipment of large mercantile vessels have been booked by the company, some work has been done in the direction of design. Plans have been prepared for an installation in a proposed ocean liner giving a total of 38,000 I. H. P. and an estimated rate of sea speed of 26 knots. The proposed vessel would have these dimensions: Length between perpendiculars, 600 feet; beam, extreme, 63 feet 3 inches; depth, molded, 42 feet; draught to bottom of keel, 28 feet; displacement, 18,000 tons; total bunker capacity, 5000 tons. Making a comparison as to machinery weights between the proposed vessel and a liner of similar dimensions with reciprocating engines of about 26,000 I. H. P. and Scotch boilers, the result would be:

	Turbine Liner Water-Tube Boilers.	Regular Type Scotch Boilers.
Boiler-room weights with water in boilers.....	1364 tons	2235 tons
Engine-room weights with auxiliary gear and water in condensers.....	822 tons	1220 tons
Shaft and propellers.....	210 tons	305 tons
Totals.....	2396 tons	3750 tons

The machinery weights of the turbine liner figure out 141 pounds per indicated horse-power, and those for the regular type liner 323 pounds per indicated horse-power. The comparative table shows a saving of 1354 tons in the machinery weights for the turbine-driven vessel over that with reciprocating engines on the same displacement, but the larger portion of this is to be credited to the water-tube boilers. In the engine-room weights taken alone the difference in weight is almost 500 tons. Were less speed required and the turbine liner powered to the extent only of the liner fitted with reciprocating engines, the saving in machinery weights would be very large and add greatly to the earning capacity of the vessel.

The advantages which, it is claimed, would result from the substitution of steam turbine machinery in a liner would be:

(1) A reduction of total engine-room weight to about one-half that of ordinary engines. (2) A small reduction in steam consumption per indicated horse-power. (3) Complete freedom from all vibration from the

main engines, and a great reduction of vibration from the screw propellers. (4) A smaller engine-room staff to deal with the simpler and lighter engines and shafting. (5) Less consumption of oil and stores.

Commenting on these claims, *Engineering*, London (to which we are indebted for many of the foregoing particulars), remarks that the perfect balancing of the engines permits of very light engine-room foundations, and obviates that stress or strain on the hull, which is produced by the reciprocating forces of ordinary engines. The absence of lubricant from the internal parts of the engines is a benefit to the condensers and boilers. It diminishes the cost of cleaning and repairs, and enables very high boiler pressures to be used without risk. It is proposed that the steam should be reheated between the high- and low-pressure cylinders by coils of steel tubes containing steam at boiler pressure. Compound feed heaters, supplied with steam drawn from several points in the expansion in the main engines, would raise the temperature of the feed to above 212 deg. Fahr. The exhaust from the auxiliaries would also be added to one or more of the heaters. The trials of the Turbinia showed a total consumption of steam for all purposes of 14½ pounds per indicated horse-power of the main engines at 31 knots, but in a liner the consumption would undoubtedly be less owing to the larger size and more perfect expansion, the higher boiler pressure, better vacuum and other minor details. Smaller size of the screw propellers diminishes vibration due to uneven action of the blades in the stream lines of the vessel. Smaller diameter also permits of some 8 feet more immersion above the tips of the blades, so that the evils of screw racing in heavy weather will be mitigated, and the vessel better able to keep her speed.

With the steam turbine the turning moment on the shafting is absolutely uniform, and these engines have much more momentum (or flywheel inertia) than ordinary engines. They will, therefore, not gather speed so quickly should the screws top the surface, and the engine governor will have more time to come into action and prevent racing. The shafting is only about one-half the usual diameter for equal total indicated horse-power, and can, therefore, be much more easily dealt with by the staff, and spare parts more easily carried. The four shafts are an additional safety against total breakdown of the engines; and should one of the engines break down the other three are not interfered with, as they are quite independent excepting as regards the steam supply, which is controlled by valves. The small headroom required for the turbine engines and their quiet working permits of cabins being placed over part of the engine-room.—*Marine Engineering.*

TRIALS OF TORPEDO-BOAT VIPER.

The Parsons turbine has again proved its ability to drive a torpedo-boat at very high speed. On the official trial of the Viper, a 325-ton destroyer for the British Navy, equipped with compound turbines of 10,000 horse-power, a speed of slightly over 32 knots, or 37 miles an hour, was realized at ¾ horse-power. When she develops her full horse-power, the contract speed of 35 knots will probably be realized.—*Marine Engineering.*

OUR NEW FLEET OF TORPEDO-BOAT DESTROYERS.

It is only of recent years that the United States Government has undertaken the construction of torpedo-boat destroyers on an extensive scale; but thanks to the acts of Congress in the years 1896, 1897 and 1898, we have now either built or building no less than thirty-seven torpedo-boats and sixteen destroyers, a total of fifty-three of these formidable little craft. At present we have no torpedo-boat destroyers proper, in commission in our navy, the nearest approach to this type being such boats as the Porter and the Dupont, of 165 tons displacement and between 28 and 29 knots speed. There are other vessels much larger than these nearing completion, if not already commissioned, which while they would undoubtedly be capable of accompanying a fleet to sea and are fully as large as some of the torpedo-boat destroyers in other navies, are not listed as such in the official tables of the Bureau of Construction and Repair. Such are the 30-knot vessels Bailey of 235 tons, Farragut of 273 tons, Goldsborough of 247.5 tons, and the Stringham, a large boat of 340 tons, which is expected to develop 30 knots with a total horse-power of 7200.

Sixteen torpedo-boat destroyers of the Bainbridge class were authorized in May of the year 1898. The contracts for these vessels were let in the fall of the same year and the contract date of completion lies in the early months of the year 1900. They are all nearly alike in the general arrangement of the engines, boilers, armament, etc. There are minor differences which are indicated in the subjoined table.

Name.	Number of Vessels.	Length.	Beam.	Draught.	Displacement, tons.	Horse-power.	Speed, knots.	Bunker capacity.	Torpedo-tubes.	Armament.
		Ft. in.	Ft. in.	Ft. in.						
Bainbridge...	9	245	23 7⅛	6 6	420	8000*	29	139	2-18 in.	2-12 pdr., 5-6 pdr.
Hopkins.....	2	244	24 6	6 0	408	7200	29	150	"	2-12 pdr., 5-6 pdr.
Lawrence	2	243 3	22 3	6 2½	400	8400	30	115	"	2-12 pdr., 5-6 pdr.
Worden	3	248	23 3	6 0	433	8300	30	232	"	2-12 pdr., 5-6 pdr.

* The Paul Jones, Perry and Preble are to indicate 7000 horse-power.

Nine of the destroyers are of 420 tons displacement and will develop speeds of 28 and 29 knots with 8000 indicated horse-power. They will be known as the Bainbridge, Barry, Chauncey, Dale, Decatur, Paul Jones, Perry, Preble and Stewart, being named after heroes whose names are associated with the most brilliant episodes of our naval history. It should be noted that the three last-named of these vessels, which are being built by the Union Iron Works, of San Francisco, are guaranteed to give a speed of 29 knots with 7000 instead of 8000 indicated horse-power. Each destroyer will carry on the main deck two torpedo-tubes for the discharge of the 18-inch Whitehead torpedo. The armament will consist of two 12-pounder rapid-fire guns carried, one forward and one aft, above the conning towers and protected by shields. There will also be five 6-pounders carried in broadside on the main deck. These vessels will have a length of 245 feet, a beam of 23 feet 7½ inches, and a draught of 6 feet 6 inches. They will be capable of carrying 139 tons of coal closely stowed in their bunkers, and the complement will consist of four

officers and sixty men. One excellent feature, which will give them considerable advantage over some of the latest boats that have been constructed for foreign navies, is that in addition to their relatively large size they are provided with a long forecastle deck which gives them an extreme freeboard forward of 14 feet, the freeboard amidships being about 9 feet. This will considerably improve their speed in steaming to windward in heavy weather. Three of these vessels are being constructed by Neafie & Levy, Philadelphia; two by William R. Trigg & Company, Richmond, Va.; three, as mentioned, by the Union Iron Works, of San Francisco; and one by the Gas Engine and Power Company, Morris Heights, N. Y.

The Hopkins and the Hull, which are being built by the Harlan & Hollingsworth Company, Wilmington, Del., are somewhat smaller vessels. They have about the same length, a foot more beam, and 6 inches less draught with a displacement of 408 tons. They are to achieve 29 knots with 7200 indicated horse-power, and the bunker capacity will be 150 tons, the armament and the complement of officers and crew being the same as for the Bainbridge. The Lawrence and the Macdonough, which are being built by the Fore River Engine Company, Weymouth, Mass., are the smallest vessels of the fleet. They will be of 400 tons displacement and they are to achieve a speed of 30 knots with 8400 indicated horse-power. The coal capacity will be less, namely, 115 tons; particulars of the armament and the complement will be the same as for the other vessels. The largest of the fleet will be the Truxton, Whipple, and Worden, building by the Maryland Steel Company, at Sparrows Point, Md. They will be 248 feet in length, 23 feet 3 inches beam, and on a draught of 6 feet they will have a displacement of 433 tons. They will have the large bunker capacity of 232 tons—a very valuable feature—and they are to make a speed of 30 knots with a development of 8300 horse-power.

These destroyers when completed cannot fail to produce a favorable impression. Their size, roominess, coal capacity, and powerful armament, and above all their good sea-going qualities, and high speed, will place them in the very front rank of this type of vessel.—*Scientific American.*

THE LAKE SUBMARINE BOAT.

Six years ago the Congress of the United States made provision for the building of a submarine torpedo-boat, and plans or designs were submitted by a number of persons. After some deliberation the award was made to the Holland Submarine Boat Company, the guiding spirit of which was John P. Holland, the inventor and builder of the much-discussed "Fenian ram" of the "seventies." Among the other plans submitted was one by Simon Lake, which, while not promising the idealism of the Holland craft, was to be able to navigate awash on the surface or totally submerged and traveling along on the bottom. To-day, the Holland boat ordered in 1894 is about 86 per cent. completed and likely to undergo serious modifications before declared ready for trial, while the Lake boat, called the Argonaut, has proved its entire practicability and is in its second edition, for a working and commercial duplicate has recently been put overboard at New York in the shape of the New Argonaut. In one of these rival boats the inventor claims that we have

a dream of the happiest sort realized, while in the other, as she lies literally tied up in Baltimore, there is the disagreeable guarantee of sudden death should aught go wrong with her while under water, and the fair assurance at all times of roasting within the cramped compass allotted to the human elements that are to control her in action.

Argonaut No. 1, as we shall call the boat of 1897, made several experimental cruises about the harbor of Baltimore and down to the head of Chesapeake Bay in the latter part of 1897 and the early months of 1898, just prior to hostilities with Spain.

Believing the Argonaut to be susceptible of naval or military application, although really built for wrecking work, Mr. Lake proceeded on an extended cruise down the Chesapeake, up some of its tributaries, and around to New York City, making no fewer than a hundred descents, and covering a distance of something like a thousand miles, all told, and in all kinds of weather. At no time was she in danger, and at no time was her complement of five persons inconvenienced or uncomfortable in any way.

The principal facts claimed to be established about the vessel were:

(1) That she could be perfectly controlled while submerged, and when rising again to the surface, or that she could be held steady, *i. e.*, immovable, at any desired depth.

(2) That she could travel on any kind of bottom. In many cases she found mud so deep that a diver who was sent out sank to his waist, yet she ran easily and freely. Much of the bottom, especially on the coast, was almost level, of hard white sand, and quite as smooth as a macadamized road.

(3 That greater speed could be obtained while submerged than when running on the surface. This was undoubtedly due to the fact that there was a much greater head of water over the screw, making it more efficient, while completely doing away with wave-making resistance.

(4) That no greater perceptible power was required to run up steep hills than when running on the level, owing, no doubt, to the fact that the vessel was kept so nearly buoyant.

(5) That the crew was as comfortable when submerged as when on the surface. The Argonaut remained below at one time for ten hours and fifteen minutes. During this time the door was opened, clams and oysters were picked up from the bottom, and the cook prepared a hot meal, consisting of clam fritters, coffee, baked beans, etc.

(6) That telephonic communication could be maintained with the outside world while the boat was submerged. From the bottom of the Patapsco River the Argonaut was in communication with Baltimore, Washington and New York.

(7) That the Argonaut is a success for finding cables, and for repairing and cutting them. By running over the bottom with the door open, a cable in the Patuxent River was picked up with a short hook, dragged into the boat, and cut.

(8) That the compass is as trustworthy under water as above it.

(9) That divers could readily pass out and into the vessel while submerged, no water coming into the boat while the door was open.

(10) That although storms raged on the surface the Argonaut, when surmerged, was not in the least affected.

The air supply and air-exhaust pipes, for the sake of mutual support, were run together like the sides of the letter A, and reached to a height

of 40 feet above the deck. This is done away with in the new boat, and flexible hose reaching up to a boat-shaped float will form the source of air supply and the means of exhaust for foul air and the gases from the engines.

Argonaut No. 1 is 36 feet long, has a beam of 9 feet, is circular in cross-section, and is of something like 57 tons displacement when entirely submerged. She is built of steel plates 3/8 inch in thickness, and double-riveted over strong steel frames spaced about 20 inches from center to center, and has a single 30 horse-power gasoline engine, which propels her both on the surface and when submerged, besides running all the auxiliary machinery for pumping, for compressing air, and for generating the energy for the electric lights. Air is stored in strong steel cylinders. All compartments have telephonic means of communication, which is further extended to the divers working without and beyond the vessel. The New Argonaut is a substantial duplication of the older Argonaut form—the cross-section also being round, but for superstructure she carries a boat, or ship-shaped structure of fine lines, which blend easily with the main body of the stouter cigar-shaped phase of the craft. In this lighter part of the craft will be carried the air tanks and the gasoline reservoirs safe from the reach of fire within the body of the boat.

On the deck of the upper body there will be a steel chart or pilot-house, from where the boat will be conned in rough weather when running awash. This pilot-house is elliptical and within it are the controlling mechanisms for the air supply, water ballast, and other things contributive to the skipper's management of the vessel. In fair weather the vessel will be steered from the top of this house, on which will stand the standard compass by which all above-water navigating will be done. Up there, practically beyond the influence of the great mass of metal within the vessel, the compass has been found remarkably true. A water-tight hatch leads down into the main body of the boat, and this will be sealed when the boat is submerged, at which time all of the navigating will be done from compartment A.

The New Argonaut is 66 feet long, has a beam of 10 feet, and weighs 100 tons. Her air tanks, which are two big Mannesmann drawn-steel tubes, are proof to a pressure of 4000 pounds per square inch, and have a capacity amounting to a 48-hour supply without surface connections. Enough fuel, in the shape of gasoline, will be carried to ensure a radius of action of 1500 miles. She is propelled by two White & Middleton gasoline engines of 60 indicated horse-power, which not only drive the screw, but also turn the two forward wheels which grip the bottom when traveling submerged. The after wheel acts as a rudder, both when on the surface and when afloat. All the wheels have a perpendicular adjustment to meet the bottom conditions.

She will also have a small 4 indicated horse-power auxiliary engine for running the incandescent lamps, providing air circulation, and for driving the air compressor. She will also have a 3-kilowatt dynamo for running the search-lights at the bow. The sand pumps, which are placed on the deck—two abreast the pilot-house and one abaft—will get their power directly from the main engines, being coupled up at will. When engaged in wrecking or in laying submarine foundations, a derrick will be adjusted to the standard of the windlass, which runs down and fastens to the cylindrical body. The bowsprit is only a hydraulic buffer to guard against damage to the boat proper in case of collision above or below water.

Taking the compartments in turn, from forward, we have, first, A, from which the boat is managed when on the bottom. Here are also the search-lights, having four outlets, the one directly ahead on top, the one directly ahead just below, and two lateral ones on the sides of this lower one. The lights have been found to yield a pretty wide zone of illumination, and one reaching far enough ahead to make navigation reasonably safe on the bottom.

Compartment B is the diver's room. Here the air is let in from the compressor till it equals the pressure of the water without; this is determined by a pet cock in the manhole plate. When the pressure has been neutralized the door is dropped, and the diver steps down and out on the rungs worked on the inner surface of the door. It has been found that the air pressure converts this room into a great sounding chamber, and messages either from the diver or to the other members remaining in the ship can be heard without recourse to the telephone receiver. Compartment C is an air lock, by which intercourse may be had with the afterbody of the ship without affecting the pressure in the diver's room. Compartment D is the living space, within which there are bunks for eight persons and lockers for their effects. Compartment E, operating-room, where are the air compressors, some of the pumps, and the registers for air and water pressures, and for depths and heel. Compartment F is the cook-room. Compartment G is the engine-room, and is too far aft to affect the comfort of the living space. Water ballast is carried in the bottom below the living and working spaces. The midship section of the keel is detachable, weighs three tons, and will be released only in case of accident. The two anchors, which are drawn into the body of the vessel by power-armed drums, have a combined weight of nearly two tons. When the vessel is to go from the top to the bottom these anchors are lowered, water is pumped into the double bottom until the buoyancy of the craft is less than the weight of the anchors. Then the wire cables are wound in over the drums, and the boat is slowly drawn down to the bottom. If she is to remain still, no more water ballast is taken in, but if she is to travel along the bottom her buoyancy is carefully reduced to suit the load the character of the bottom will stand, and the anchors are housed as before. This loss of buoyancy or pressure upon the bottom varies all the way from a few pounds to a couple of tons, just as the soil and the currents may require. In the body of the boat there are two rectangular side or dead-lights on each side, but they are of no use save to let in light when near the surface. Hand pumps are fitted as an emergency precaution in case of breakdown in the others. The vessel will be able to make quite six knots even on a muddy bottom—the older boat made five—while on the surface she should do eight. The commercial ends to which the New Argonaut will be put will be in laying submarine foundations, recovering treasure from well-known wrecks, finding sponge beds, coral formations and pearl fisheries in the West Indies. The powerful sand pumps make subaqueous excavation a matter of ease.

The military or naval use in either mining or countermining waterways is easily apparent, while with a few additional features it is easy to convert her into a submarine torpedo-boat of an offensive character. She can be held at any desired depth between the surface and the bottom, and the moral effect of the suspected presence of such a craft is not hard to imagine.

All that is claimed for this boat has been claimed before for other boats of the kind, and the promise has not been fulfilled. Perhaps the new boat is to prove the exception. We shall see.—*The Engineer*.

A commission has just been appointed by the French Prefect of Marine for the purpose of carrying out experiments with the submarine navigation of a new type of boat specially constructed by the inventor, Goubet. The boat in question, which is quite different from the first submarine boat, the Goubet, arrived by rail at Toulon on Wednesday morning of last week, and was at once taken to the arsenal. Its form is very striking. Almost spherical in shape, it is about 3 meters in depth, 3 meters in beam, and 4 meters in length. It is propelled by a screw with a diameter of 80 centimeters, and two fins or rudders are placed port and starboard for manœuvring the boat when it is submerged.—*The Engineer*.

FRENCH SUBMARINE BOATS.

The flotilla of submarine boats in France promises to present as great a variety of types as the battleships. After the enthusiasm following upon the performances of the Gustave Zede had simmered down, and people began to look at it from a more practical standpoint, it was recognized that its small range of action was calculated to lessen considerably its utility as a war engine. The new vessel, it was said, had at any rate proved the practicability of the submarine boat, and in the hope of getting something better the naval authorities gave fresh attention to the somewhat despised Goubet boat. This vessel, however, showed a tendency to dive to the bottom and stay there, and the naval experts begin to pin their faith in boats of the Morse type. Recent trials with the Morse submarine showed that as regards the range of action it had scarcely any advantage over the Gustave Zede, and it had to be admitted that the boat could not be used for any other purpose than harbor defense. After all these experiments, however, it did not seem as if much headway had been made, but the naval department, with praiseworthy optimism conveyed its favors to the Narval, simply because absolutely nothing was known as to the behaviour of this type of vessel, and plenty of scope was consequently allowed for the exercise of a vivid imagination. The Narval has been constructed upon the plans of M. Laubeuf, a naval engineer, who secured the gold medal in the competition for submarine-boat projects organized by M. Lockroy. She was put upon the stocks at Cherbourg in July, 1898. Constructed of steel, she has a length of 34 m., a width of 3.75 m., and draws 1.60 m. of water when navigating at the surface. Her displacement is 160 tons. The motive power is supplied by a Forest oil engine, which not only drives the propeller when the boat is either navigating at the surface or with only her look-out and chimney exposed, but also operates a dynamo for charging batteries of accumulators, these being used to propel the boat when she is entirely submerged and the chimney unshipped. Sailing at the surface at 12 knots, the Narval promises a range of action of 252 miles, and at eight knots the range is to be 624 miles. When submerged the accumulators will propel the boat twenty-five miles at eight knots, and seventy miles at five knots. The Narval is equipped with four torpedo-tubes, and carries two officers and

nine men. The boat was launched at Cherbourg last week, and the greatest interest is being taken on the other side of the Channel in her forthcoming trials, and it is this type of vessel which carries the hopes of France.—*The Engineer.*

THE IMPROVED GOUBET SUBMARINE TORPEDO-BOAT.

Of the many men who have endeavored to invent a practicable submarine boat, says Stein der Weisen, the French engineer, Goubet, seems to have been most successful in solving the problem of keeping the submerged vessel in equilibrium.

The apparatus by which this is accomplished is automatic in its operation, and is constructed on the principle of the balance. As the boat inclines from an even keel a double-acting pump is made to discharge water from a reservoir in the stern to another reservoir in the bow, or vice versa. The receptacles hence resemble the hands of a balance, and the weights represented by the water are shifted from one pan to another. The pumping of the water from one tank to the other is effected so rapidly that the vessel is almost immediately returned to an even keel.

The length of the boat is 8 meters (26.24 feet). The motive power is derived from accumulator batteries of sufficient capacity to drive the boat for fourteen hours. Enough compressed air is carried to supply the crew of two men with fresh air for eight hours. The screw of the boat is so arranged that it can be adjusted to all sides. The usual rudder is hence dispensed with. The boat, by reason of its adjustable screw, can be directed not only to the right or to the left, but upward or downward. At the stern of the boat a torpedo-tube is mounted by means of which a torpedo can be discharged upwardly against the bottom of a vessel, where it is exploded electrically from the boat. The vessel is also provided at its nose with a device by means of which the cables of harbor mines can be cut. The light necessary for this operation is provided by an electric light mounted in the nose.

This boat is known as the Goubet I. The inventor has, however, made various improvements which he has embodied in a new vessel called the Goubet II. In the later boat access is had to the interior by means of a ladder which is removed before the dome is closed. The cover for the dome is rendered water-tight by a rubber packing. In the Goubet I there was so little room that the two men who composed the crew were compelled to sit back to back in the center of the boat; the Goubet II is much roomier. The commander takes his position amidships in a revolving chair, so that he can see in every direction through the dome. His two assistants have charge of certain apparatus and are stationed at the ends of the boat with their faces turned to the center. The man at the bow manipulates two levers, by means of which the valves of the water ballast are controlled. Behind his head is a tube in which a receptacle inclosing messages is placed; the vessel having a specific gravity less than that of water will rise to the surface to be received by friends above.

The electric motor is located in the stern and is driven by batteries placed beneath the deck timbers. Above the motor is a hand-wheel by means of which the screw propeller can be moved to any position. The

tubes are located at each side of the vessel. An apparatus is also provided for releasing the leaden keel in order to enable the boat to rise rapidly.

Ordinarily the Goubet II travels partially submerged on the surface, so that only its dome is visible. When near a hostile vessel the Goubet is sunk to a depth of 4 or 5 meters, or if necessary to a depth of 10 meters. When submerged the lookout can see nothing through the dome; for which reason a periscope is used when the depths are not great. It is of the utmost importance to maintain the vessel so far as possible at a constant depth. This is effected by an ingenious automatically operating apparatus comprising essentially a gage which indicates the water pressure and thus the depth at which the boat may happen to be. As the finger of the gage travels over a contact arc it breaks or completes an electric circuit and thus controls the water ballast pump.

The motor of the Goubet II is of 2 to 3 indicated horse-power. In the latest type of vessel mercury sulphate batteries are used instead of accumulators, because the latter generate hydrogen gas which forms an explosive compound with air.

As the air in the interior of the vessel becomes vitiated by the breathing of the crew, it is pumped out of the boat, while fresh air from the compressed air supply is allowed to take its place. Carbon dioxide gas is absorbed by potash; while the moisture and organic products breathed out are absorbed by calcium chloride. Under these conditions the boat can remain under water for from ten to fifteen hours.—*Scientific American Supplement.*

SUCCESSFUL TRIALS OF THE HOLLAND SUBMARINE BOAT.

The naval board appointed to inspect and report on the performance of the Holland submarine boat has reported that in the recent tests, held on November 6, in New York harbor, she fulfilled all the requirements laid down by the department. These requirements were that she should have three torpedoes in place in the boat, she should have all arrangements for charging torpedoes without delay, and that she should be prepared to fire a torpedo at full speed both when submerged and at the surface. Lastly, the Holland was to make a run for two miles under water, starting from one buoy, running submerged for a mile to a second buoy, rising to discharge a torpedo at a mark near the second buoy, and then after diving again return submerged to the starting point.

In his report, Chief Engineer John Lowe, U. S. N., who was specially ordered to observe and report the preliminary trials, says:

"I report my belief, after full examination, that the Holland is a successful and veritable submarine torpedo-boat, capable of making a veritable attack upon the enemy unseen and undetectable, and that, therefore, she is an engine of warfare of terrible potency which the government must necessarily adopt into its service."

He further says that "this government should at once purchase the Holland and not let the secrets of the invention get out of the United States, and that the government ought to create a submarine torpedo-boat station for the purpose of practice and drilling of crews, and that we need right off and right now fifty submarine torpedo vessels in Long

Island Sound to protect New York, preserve the peace, and to give potency to our diplomacy."

While we cannot agree with Mr. Lowe in his opinion that we need and presumably should build a whole fleet of torpedo-boats "right off and right now," we do think that the Plunger, a larger boat of the Holland type now building for the government, should be immediately completed and further trials of the system carried out.—*Scientific American.*

TORPEDO DISCHARGE BELOW WATER.[1]

By CAPTAIN LLOYD, late Royal Navy.

The author commences by referring to the modern form of Whitehead torpedo, and gives a brief account of the part it had played in naval warfare since its invention. Owing to the objections raised against above-water discharge, it has at last been recognized that nothing lies between abolishing the use of the torpedo from large vessels and the adoption of discharge below water-line.

The problem of ejecting the torpedo from the broadside below water is a very difficult one, for then the stream of water, passing at right angles to the direction of ejection, has to be contended with. No apparatus would be considered satisfactory unless ejection could be carried out at a high speed of ship, say 17 knots, and calculations had shown that at that speed the stream of water impinging on a cylindrical surface would impose a pressure of 634 pounds per square foot of sectional (longitudinal) area, or in the case of an ordinary Whitehead torpedo, a total pressure of 5.2 tons. The principle on which almost all submerged discharge apparatus has been designed, is to rig out a shield which is also sometimes called a spoon, sometimes a bar. There are grooves of some form in this shield, and guides on the torpedo, which fit into the grooves. In this way the torpedo is supported against the streams of passing water, and guided so that its axis remains coincident with the axis of the submerged tube, until the tail of the torpedo is clear of the ship's side. In fact, the shield is made of such length that the guides on the torpedo run out of the grooves in the shield at the same moment, or shortly after the tail clears. Whilst the torpedo is traveling along the shield, the head or the part in front of the guides will become more and more exposed to pressure from the passing water, whilst the tail or part in rear of the guides will always be more or less protected from pressure by the shield. One point to be observed in designing the shield is to arrange it so that the streams of water may pass through it as much as possible, and by exerting pressure on the rear part of the torpedo, do something towards balancing the pressure or weight on the front part. Much can also be done in this direction by placing the guides as far forward along the torpedo as possible. But there must always be a want of equilibrium, and this must cause a certain amount of deflection. If, however, the deflection is constant, and is known, it should not cause bad practice. It is a curious fact, revealed and confirmed by practice, that the deflection is constant for all speeds, nor does this deflection appear to be influenced by the angle of the tube to the ship's keel.

In the Elswick apparatus the shield or spoon is a cylinder with the after side removed. The front side is perforated as much as possible with

[1] A paper read before the British Association.

ports so as to allow the water streams to pass through and help to balance the pressure of water on the torpedo. The shield is provided with double grooves on the top and bottom, to guide the torpedo. For the ejection of a torpedo three distinct operations take place: 1. The shield to be run out. 2. The torpedo ejected. 3. The shield withdrawn. If these operations be done separately, either a ship must go into action with the shield already out, or there must be delay to be allowed for, before firing. In the Elswick apparatus all three operations are combined. If the shield or spoon, and the torpedo be ejected actually together, the two motions being independent of each other, there may always be the risk of some cause impeding the shield, while the torpedo pursues its course. The torpedo guides would, under such circumstances, leave the grooves in the shield before the latter was entirely out, and the torpedo would certainly be injured or deflected abnormally. In the Elswick design, for the two actions, those of running out the shield, and ejecting the torpedo, are dependent one on the other. After the torpedo has gone, the pressure which ejected it is allowed to escape and the head of water forces back the spoon. The apparatus consists of two principal parts, the inner tube and the outer tube. The inner tube is made in two parts, the shield or spoon, and the rear end, but these two parts are bolted together. The grooves to guide the torpedo run from one end to the other of the inner tube, on the top and bottom, and the rear end is closed by a door in which is fitted the axial valve for controlling the admission of pressure to the torpedo.

The outer tube encloses the inner tube. It is fitted at about half its length with a gland box through which the rear end of the inner tube passes. The front end of the outer tube is attached to the sluice valve casing, the rear end is fitted with a door, and on the top of the tube is placed the explosion chamber or air reservoir, or frequently both. The explosive preferred by the author's firm is cordite, which is quite clean, and is a slow-burning explosive. The cordite charge is ignited, causing a pressure of about 850 pounds to the square inch in the explosion chamber. The gases escaping from this chamber have to pass through a plate having in it a number of small perforations. The passage through these small holes insures that the pressure on the other side of the perforated plate does not exceed 100 pounds. Thus, while retaining a sufficiently high pressure in the explosion chamber to burn the cordite, there is a moderate pressure to set the inner tube in motion. The pressure falls to under 40 pounds by the time the tube has got out 6 feet. At this point a valve known as the axial valve opens and the pressure is communicated to the torpedo. The axial valve is fitted in the rear door of the inner tube and is loaded by a spring tending to keep it shut. It is locked or freed by a lever which travels in a groove cut in a plate attached to the outer tube, so that when the inner tube is right back the valve is firmly locked. When the tube has traveled rather more than a foot, the lever is slightly raised and the valve is allowed to open a very little, and when the tube has traveled 5 feet 6 inches the lever is lifted its full travel, these motions of the lever being controlled by undulations in the groove. The valve is thus unlocked, and the pressure at the back of it forces it open, and the final ejection of the torpedo from the inner tube takes place. After the departure of the torpedo the gases will escape by the axial valve until the pressure behind the tube equals the pressure due to the head of water plus the pressure exerted by the spring which loads

the valve. This last load is 1 pound per square inch. If air impulse be used, and there was no other exit for the air but the axial valve, it is evident that the tube would not return. With cordite, however, the fall of pressure due to loss of heat soon assures the pressure behind the tube, tending to keep it out, being reduced below the pressure of the head of water tending to force it in. In any case, however, there must be a decided interval between the moment of opening the valve and the running in of the tube. During this interval the final ejection of the torpedo takes place, and the torpedo clears the spoon. The interval varies, but that is quite immaterial, providing that the torpedo clears before the tube commences to run in. The tubes are generally installed with their axes about 10 feet below the water-line. The pressure due to the head is therefore approximately 4½ pounds per square inch. The sectional area of the inner tube being 500 square inches, there is a total pressure of 1 ton to force the tube in, in opposition to the friction caused principally by the packing which surrounds the inner tube, and by the load imposed upon the bearing surfaces of the spoon by the passing streams of water. The rear end of the outer tube is fitted with three drain valves. These are supplied with springs tending to keep them open. The pressure employed during the ejection of the torpedo is, however, ample to close them. When that pressure is reduced after ejection of the torpedo, the springs open the drain valves, which then let the pressure, whether caused by compressed air or by cordite gases, escape, so that the pressure due to the head of water tending to force the tube in is unbalanced, and the tube returns. The drain valves, however, are small, and if the tube comes in too fast the pressure behind it cannot escape quickly enough, the drain valves close, and the motion of the tube is checked. Although the automatic return of the inner tube can be generally relied upon, it is apparently desirable to have some alternative method of running it back. Hand gear is, therefore, provided for this purpose.

A short discussion followed the reading of this paper. Mr. Mark Robinson pointed out that under-water discharge was known before, though the details mentioned by the author had been specially devised. Another speaker asked if any provision was made against deflection of the tube.

Sir William White said that the apparatus described by the author in his paper afforded a beautiful example of difficulties being overcome by mechanical arrangement. In regard to the perfectly true remark of Mr. Robinson, under-water discharge of the fish torpedoes was known in the navy 20 years ago, but Captain Lloyd doubtless did not wish to make any comparison between various systems, and simply related what had been done at Elswick. Perhaps it should be stated that before Captain Lloyd took up his present position with the Armstrong firm, he was a distinguished officer in the Royal Navy. Mr. C. A. Parsons asked what was the maximum speed of a ship at which a torpedo could be discharged with safety. Another speaker asked how the pressure was communicated to the torpedo.

In replying to the discussion, Captain Lloyd stated that by means of an axial valve, which is situated at the rear end of the inner tube, the pressure impinges on the torpedo at the proper instant, so that it is shot out by the gases of explosion at the moment. It may here be explained that the outer tube is a fixture attached to the ship's side, the outer end having a valve by the opening of which the torpedo can be

ejected. Inside the outer tube the inner tube slides telescopically, and inside the inner tube the torpedo is placed. When the inner tube is slid back, and the sluice valve in the ship's side is closed, so as to prevent access of water, a door at the rear end of the tube is opened and the torpedo inserted after the manner of a projectile in a breech-loading gun. The torpedo is now inside the inner tube of the telescope, and the door which is in the rear of that tube contains the axial valve. The cartridge is placed in the outer tube, and when fired it forces the inner tube out, and with it the spoon or guide. At a given distance of travel the axial valve opens and admits pressure behind the torpedo, which is thus sent on its course. The pressure due to the head of water outside the ship then pushes the tube back, and the sluice valve can be closed. In regard to the deflection of the inner tube, the author said it would be understood that this was immensely strong, but however stiff they might try to make it, it would bend a little owing to the pressure of the water upon it. They therefore, in making it, gave it a slight bend the wrong way, so that when pressure was brought upon it, it would tend to straighten. There were three guides on the torpedo, and if the tube were too much bent the middle guide would not engage. This would throw too much stress on the guide at the tail, and the after part was that which was most delicate, and therefore should not be strained. In regard to speed, they had fired a large number of rounds at 17 knots with safety. In the Brazilian Navy—and he mentioned this more especially because some people in this country seemed to think that the Brazilians were not very enterprising—a large number of experiments had been carried out with complete success.—*Engineering.*

THE PROGRESS OF THE AMERICAN NAVY.

The full strength of the navy of the United States now amounts to 312 vessels of all kinds, built and building. Of this number 189 are in the regular navy and 123 constitute the auxiliary force, for the accumulation of which we are largely indebted to the necessities of the Spanish-American war. Something of the pace at which we are moving forward may be imagined when it is stated that roughly estimated the existing naval fleet represents an expenditure for construction of about 125,000,000 dollars, and yet there are now under construction or awaiting formal acceptance by the government more than half a hundred war vessels, the contract price for which, exclusive of armor and armament, is in the neighborhood of 40,000,000 dollars. The war almost doubled the aggregate of men on our war vessels. At the outset the complement was 12,500 men, but in the summer of 1898 it reached the maximum figure of 24,123 men. Since that time it has, of course, decreased considerably, but the incoming Congress is expected to authorize a permanent naval strength of upwards of 20,000 men. Nor, in passing, should mention be omitted of the success which has attended the amalgamation of the line and staff. An experiment watched by students of naval administration everywhere, its beneficial effects have been discernible instantaneously.

For the future, bright hopes may be based upon the most favorable of indications. Congressmen have been spending the summer of 1899 in the study of naval science abroad. Places on the naval committee have been eagerly sought. Already a new atmosphere of liberality and intel-

ligence characterizes the consideration of naval problems and affords ground for hope that never again will the march of progress be retarded by such a lack of knowledge as made possible the late fiasco relative to the limitation of armor prices. New battleships, armored and protected cruisers are to be constructed. Each class is quite certain to mark a step forward in the science of building vessels of war. Rear-Admiral George W. Melville declares to the *Review* that the new battleships should be of 20 knots speed; that they should carry large batteries of rapid-fire guns; have ample coal-bunker capacity, and be fitted with triple screws—radical revolutionary measures, all, but vital in influence if successful. Already the eyes of every naval officer across the Atlantic are upon us. Within the past month two of our new battleships have exceeded contract speed. The practicability of that most novel of ideas—the superimposed turrets of the Kearsarge—will soon be put to the test. We are preparing to outdo the British in the thoroughness of our experiments with liquid fuel and wireless telegraphy. Finally we are investigating the possibilities of the submarine boat and our conclusions will have enhanced value because they will be characterized by neither the enthusiastic optimism of the French or the cynicism of the conservative Britons. For well-rounded naval development every essential must be adequate. Thus there is no greater cause for congratulation than over the manner in which the shipyards of America have met the requirements imposed by new conditions. The past few years have seen no less than half a dozen firms actively engaged upon naval contracts, although their previous experience had been entirely confined to mercantile craft. Several of them, at the initial attempt, constructed vessels which exceeded contract speed.

Heretofore the powers have charged us with being deficient in the matter of diversity of strength in our naval fleet. This is true no longer, for with the completion of the vessels now on the stocks we will have more than half a hundred torpedo-boats and destroyers. Here, too, American builders have been daring, for who will contend that it is not venturesome to guarantee a speed in excess of 30 knots on a smaller displacement than has ever before been attempted by any shipbuilder the world over—and that, too, when the contract is the first of the torpedo-boat kind for the firm undertaking it? Even down to the details the United States Navy will be unique. No other nation has found so appropriate a form of designation for its fighting craft. Our states have given us names for two dozen; two score of our cities have namesakes in our navy, and finally no less than thirty of our naval heroes have had their names commemorated by war vessels. It is a novel navy and a magnificent one, and with its strength considered, it is the most interesting on the waters of the earth.—*Marine Review.*

A SIX-MASTED SCHOONER.

Mr. H. M. Bean, at Camden, Me., is building a six-masted schooner, which will register about 2750 net tons, and will carry from 5000 to 5500 tons of coal. Thirty years ago the average schooner built in this part of the world was of from 100 to 250 tons register. Then, along in the early seventies they began to build three-masters slightly larger, and the size was increased gradually to about 500 or 600 tons in 1880. In the eighties there was a demand for larger vessels for the coasting trade, and

the size of the three-masters went up to from 600 to 900 tons, with a coal-carrying capacity of from 1000 to 1400 tons. Late in the eighties a few four-masters were built, and then, in 1888, at Waldoboro, was launched the first five-master, the Gov. Ames, of 1689 tons net. This vessel was the wonder of her time, and it was predicted that she would prove a lamentable failure. She has been a great success, however, and not alone in coasting, for she has been around the Horn to the Pacific and back again, carrying 1,650,000 feet of Oregon pine to Liverpool, besides making several voyages from Puget Sound to Port Pirie, Australia. In recent years several four-masters have been built that are larger than the Gov. Ames, among them the Frank A. Palmer, of Bath, of 1832 tons, now on the way to Tampa, Fla., with a cargo of stone for the fortifications there. The latest wonders in the big schooner line are the John B. Prescott, built at Camden, and Nathaniel T. Palmer, built at Bath, both launched last winter. These vessels are of the five-master type, each registering about 2245 tons and carrying from 4000 to 4400 tons of coal, according to weather, voyage and draught. Two five-masters of less tonnage have since been launched at Bath. The new six-masted schooner being constructed at Camden will be 310 feet in length on the keel, 345 feet on deck, and will carry 5500 tons of coal on a draught of 24 feet. It is interesting to roughly estimate the earnings of a vessel of this class. As shown by the records of other schooners, there is a possibility of this vessel's making 18 trips a year. Some of the big schooners in the coal trade average over 20 cargoes a year. At 18 cargoes the schooner will carry 99,000 tons of coal in a year. Averaging 70 cents per ton, trimming included, the gross earnings for a year would be $69,300, 70 per cent. on the original investment. The two bills on such a vessel would average $6000 a year, the wages of the officers and crew $7000, food bills $3000, water and coal $500, incidentals, allowing for renewal of running rigging and for bursted sails and repairs, $5000, making a total of $21,500, leaving a profit of $47,800, or over 47 per cent. Insurance on vessels averages about 7 per cent., and there would be left a net profit of better than 40 per cent. This is what such a vessel might do with extra good luck. Under the most adverse circumstances she would not make less than 12 trips a year, and would even then pay 27 per cent.—*Nautical Gazette, N. Y.*

AMERICAN SHIPPING AND SHIPBUILDING.

As the time for the assembling of the United States Congress approaches speculation is quickened as to the course which will be adopted with regard to shipping. Our own belief is that we are on the eve of a vast and severe competition for our well-earned supremacy as shipbuilders and sea-carriers. Those who have followed the course of the shipping subsidy movement in the United States, and who know the conditions of politics in that country, cannot but be impressed with the significance of the portents. There is a world of meaning in the fact that Mr. T. B. Reed will not occupy the Speaker's chair in the new Congress, for it was really Mr. Reed who blocked the last shipping subsidies bill in the House. This is a little difficult for those to understand who think of the chairman of the American House of Representatives as an impartial instrument of authority, and nothing more—like our own Speaker of the House of Commons. But unlike him, the American speaker is the leader

of the party which is in a majority in the House. He not only orders the method of procedure of his party, but as chairman of the committee on rules, he arranges the order of all the business of the House. When he does not wish a measure to pass he can so arrange the order of business as to block it. And this is what Speaker Reed did with the shipping subsidies bill, which he regarded as a measure that might well wait for a more convenient season. Not Mr. Reed, however, but the nominee of Mr. Hanna, will occupy the speaker's chair in the new House. And we have to remember in this connection that Senator Hanna introduced the shipping bill that was adopted by the Senate, after it had been amended by Senator Frye; and that the Republicans—of which Mr. Hanna is boss—have an absolute majority in both houses.

We may take it, then, that if a shipping subsidies bill is reintroduced as a party measure, it will surely pass into law in the coming session. And that such a bill will be introduced there is not room to doubt. Our information is that it is already drafted, with the hearty approval of the party leaders, and we have reason to believe that the prospects are regarded with serious misgiving by some of our leading shipowners. The new bill will probably be a modification of the Hanna-Frye bill. The immediate object in view is the re-creation of an American mercantile marine, but that object can only be attained, in the peculiar conditions of politics and "interests" in America, by the fostering of an American shipbuilding industry on a great scale. There is no doubt a growing feeling of opposition to, and fear of, the great monopolies that have grown up under the tariff, but there is also a very widespread desire that the United States should have a merchant navy again worthy of her importance, and that as soon as possible. The original subsidies bill of last session was bluntly enough denounced as one of the biggest jobs ever placed before Congress; but the Frye amendments brought the "job" within limits by providing that the treasury should spend on subsidies no more than nine million dollars in any one fiscal year. And it is expected that the new bill will considerably enlarge the first section of the Frye bill, under which half bounties were to be payable on foreign-built ships admitted to the American register, provided the owners engage to build a similar amount of tonnage in the United States within five years. For the encouragement of shipping, the expansion of which is in turn to encourage shipbuilding, it is expected that the new bill will admit to full bounty privileges all foreign-built vessels acquired or contracted for by Americans prior to the passing of the act. And it is in anticipation of this provision that conditional contracts have been placed by Americans with British shipbuilders, as was referred to in our shipbuilding article recently.

But it is not realized in this country how much iron shipbuilding has already developed in the United States under the stimulus of the war, and of the prospective certainty of some such measure as the Frye bill being soon passed into law. Of course we all know how America took the lead in the good old days of wooden clippers, but all do not know how vigorous an infant now is the iron shipbuilding industry there. The government building yards have grown enormously since the United States began, in 1884, to build her own warships. At that time there were only three establishments for building iron vessels in the whole Union, and there were only four American-built ocean steamers of iron afloat. At the present time there are between forty and fifty steel vessels

of various classes in process of construction for the United States Navy, in no fewer than sixteen different yards, of which three are on the Pacific coast. These vessels range from first-class battleships to small torpedo-boats, and all the material till now has been of American manufacture, though of late some purchases have had to be made in Great Britain, owing to some of the American producers not being able to deliver in time to meet the requirements of the naval contracts. The American official returns are difficult to compare with our own, because the American fiscal year ends at June 30th; but in the last fiscal year the amount of steel tonnage alone built in the States was 134,000 tons. In the present fiscal year that tonnage will be at least doubled, and may reach 300,000 tons. Now this means both great and rapid development. Besides the naval work we have mentioned, every shipyard in the country is reported to be full of merchant work, and is extending its area. At Camden, Delaware, is being put up an entirely new establishment, which when complete will rank as the largest building yard on the Atlantic coast. This new yard will cover an area of 125 acres; it will be adapted for the building of first-class warships of the largest size; and it will have a graving dock 800 feet long for the reception of ocean liners, of which a specialty is to be made.

All the Atlantic shipyards are now engaged on naval construction work, as well as the repair work at the three government yards at Norfolk, Va., Philadelphia and Brooklyn. The Norfolk yard is an old establishment, dating back to the days of wooden frigates, and during the civil war it was the object of severe contention between the rival forces. It has been reconstructed on modern lines, and is now adapted to the construction and repair of warships of the latest type, though it has not been able to make much of some of the damaged vessels captured from the Spaniards. The Norfolk yard is, however, chiefly used for repair purposes; and, indeed, there has been comparatively little building in any of the government yards of late years, Congress seeming to prefer to encourage private enterprise by letting out all new work on contract. There is little doubt that this has had material effect in attracting capital to, and stimulating development in, the shipbuilding industry within the last year or two; and it is to be remembered that the private yards are not subject to the wage and labor conditions applied by Congress to the government establishments, though an effort was made last Congress to make them applicable to all government work, wherever done. The Philadelphia—League Island—yard has also been used almost exclusively for repairs, but it is declared to be an ideal place for building, and will be so utilized in the future. At the Brooklyn yard are the largest dry docks in the country, though at League Island a still larger one is in course of construction under a vote of last Congress.

Meanwhile, however, all the additions to the United States Navy are being made by private builders under government inspection, and fifty vessels of all sorts is a large order. Pending the completion of the Camden yard, the largest shipbuilding establishments now in operation are those of the Newport News Shipbuilding Company, Virginia; of the Cramp Company at Philadelphia; and of the Harlan-Hollingsworth Company at Wilmington. But another large yard is being brought into operation on the Pacific coast at Seattle, in the State of Washington, for the building of steamers for the Pacific trade. The obstacle to the development on the Pacific coast is, of course, the long carriage on material, the

nearest base of supply for which is Chicago. Notwithstanding this difficulty, shipbuilding is developing steadily there. Two battleships are now being built in the San Francisco yard which turned out the famous Oregon, and which has also built warships for Japan. A large fleet of merchant vessels is wanted for the Pacific, and it is found cheaper to build them of deported material on the Pacific coast than to build them on the Atlantic and send the ships round Cape Horn. At San Francisco, as well as at the new yards at Seattle, quite a number of high-class large ocean steamers for the Pacific trade are being built—the largest merchant steamers, we believe, as yet built in the States.

The United States Commissioner of Navigation recently estimated, whilst gathering material for his annual report, that not fewer than 1000 vessels were added to the American register during the last fiscal year, including, of course, vessels purchased from foreigners and vessels intended for the inland waters only. We cannot yet tell how much of that tonnage comes into the ocean-carrying trade. But the Commissioner of Navigation has prepared tables to show the effect which the proposed shipping legislation will have upon shipping, on the assumption that the subsidies will merely "offset" the higher cost of construction and operation in the United States. He also regards the subsidies as an "offset" to payments under British mail contracts, which is a fallacy, for under our mail contracts we merely pay for services rendered—that is to say, the so-called mail subsidies are just freightage for goods carried. Of more importance, to our mind, than the subsidies proposed by Senator Hanna is the fact that the cost of production of iron and steel in the future promises to be considerably lower in the United States than in this country. We do not refer to present conditions, which are abnormal, but to the conditions which will prevail when the present excitement has abated.—*The Statist.*

THE POSSIBILITIES OF LIQUID AIR.

By Elihu Thomson.

At the outset it must be understood that in dealing with the present subject the writer does not wish it to be inferred that what he calls possibilities are, in his judgment, probabilities of the near future, or, that we are upon the eve of any great revolution in engineering methods as the outcome of the recent laboratory studies of liquid air. Much further study and much additional data are required before anything more than mere suggestion can be made in this fascinating field; for, say what we may, the subject possesses an attraction for those who are accustomed to look ahead, remembering that the laboratory experiments of one day and generation have often in the past become the foundations of great industries. It took three-quarters of a century for Davy's electric arc to develop into the beginnings of commercial arc-lighting, and nearly fifty years elapsed after Faraday's brilliant researches in magneto-electricity before dynamos became a part of engineering. Yet Faraday had built a primitive dynamo and its reversed form was known in primitive types of electric motor.

The object of the present article will be to suggest, rather than predict, directions in which, under certain conditions, liquid air may possibly become a factor in engineering. And in the absence of favorable conditions need it be said that such possibilities will *not* be capable of realization?

Let us assume the availability of some innocuous gas liquefiable at about one hundred atmospheres pressure, at temperatures easily and cheaply attained, and at no cost for the gas itself. In such a case there can be no doubt of its soon finding enormous application in the storage and recovery of energy. Cheap power would be used to compress and liquefy it, after which it would be stored in quantity, either in atmospheric pressure or at some selected higher pressure. Such a liquefied gas would be stable, or remain in a liquid state, if heat were prevented from reaching it. This could be done, not perfectly of course, by surrounding the containing vessel with a liberal thickness of some good non-conductor of heat. That part of the gas which would inevitably escape on account of the lack of perfect heat-insulation would be cold and would be made to reverse the non-conducting covering in successive layers from within outward, and thus assist in cooling the covering and in preventing access of heat to the liquid; or, the escaping gas might even be made available for power in an engine, if the liquid were kept under a proper working-pressure. In this case further heating of the gas, analogous to super-heating of steam, could be employed before sending it to the engine. But little of the energy of the heat so added would be lost, and a considerable part of it could be supplied by the surrounding air or by water.

With such a liquefied gas produced at one place by cheap power and carried to another for evaporation and recovery of power, ice could be made as a by-product.

In many plants used for the development of power on a large scale, a twenty-four hours' output is not called for, but could be attained at but slight additional expense. The excess power from such a plant needs some means of utilization. This excess power, as during periods of otherwise light load, could be employed to liquefy the assumed gas. On a large scale this procedure would not be costly, supposing use of highly developed machinery. The liquid product could then be transported in tanks provided with heavy lagging and special arrangements to prevent access of heat from the outside. Perhaps it could be distributed by a well-covered pipe-line. The unavoidable evaporation which would be involved in the pipe-line transportation might not be altogether a loss, for if the line be under a pressure suitable for engines the escaping gas might possibly be tapped out at intervals, heated, and used for power along the line of way.

But the foregoing considerations are based upon the existence of a gas at no cost, with desirable properties rendering its liquefaction easy. Such a gas does not in fact exist. There then arises the question whether we can render available any of the gas known to us. Carbonic acid gas is cheap, but still far too costly for use in the way proposed. It would not pay to send it back long distances for recompressure and reliquefaction. It costs too much to be thrown away after it has been once used.

The air itself meets the condition at no cost for material in the case. We owe much the larger part of our present knowledge of the properties of liquid air to a brilliant series of investigations undertaken some years ago by Professor Dewar at the Royal Institution in London, and continued later by Professors Dewar and Fleming conjointly. The effects of the exceedingly low temperature attained by the evaporation of liquid air, upon electric conductors, dielectrics, electrolytes, etc., have been carefully studied by them. Few are able to appreciate the labor and painstaking effort that must have been expended on these researches.

In culmination, Professor Dewar has indeed lately succeeded in reducing even hydrogen to a liquid and in collecting quantities of it. Temperatures not far removed from absolute zero (—273 degs. C.) are obtained by the evaporation of liquid hydrogen. But the absolute zero, like the dynamo of 100 per cent. efficiency, may by each advance be more and more closely approximated but never reached. This low-temperature research has shown that at temperatures as low as —200 degs. C., attainable by evaporation of liquid air, conducting metals, as copper, platinum, silver, etc., when in a very pure state, have their conductivities so much enhanced that electric currents flow with but a fraction of the resistance experienced at ordinary temperatures. Research has shown that at absolute zero they would become perfect conductors. Professors Dewar and Fleming also found that liquid air is a very perfect insulator, and that ice and many frozen electrolytes even become excellent insulators at the temperatures of liquid air; and in general that intense cold in insulators improves the insulation, just as it improves the conductivity of conducting metals when they are pure.

Unfortunately, however, the liquefaction of air requires rather extreme conditions, and in the early work of Dewar was an exceedingly costly process.

The discovery of the fact that air compressed, cooled and collected in a reservoir at from 100 to 150 atmospheres might be made to liquefy a portion of its own volume, rendered possible the procuring of liquid air by a more direct and simple means. The discovery is claimed by several persons, the merits of whose claims will not be here discussed. When highly compressed air escapes from a suitable orifice it is cooled by its own expansion. If the cooled air be now caused to circulate around a long coiled pipe, which brings the compressed air to the jet in such a way that the position of the pipe nearest the jet is the first to be met by the cooled air, and so back progressively from the jet; further, if the whole be thoroughly jacketed by a non-conducting covering, the temperature of the jet soon falls sufficiently low to cause liquefaction of a portion of the air even at ordinary atmospheric pressure. The operation itself is cumulative or self-intensifying, since the cooling due to expansion is employed, on the regenerator principle, to cool most effectively the compressed gas on its way to the jet and ready to expand.

If air be compressed to about 800 atmospheres it may be made to occupy the same space as it does when liquefied, but even at the higher pressures it would remain gaseous. Ordinary temperatures of the surrounding air are far above the critical temperatures of the gases composing it. In order that it may liquefy, it must lose kinetic energy, or be cooled; velocity of the moving molecules must be brought down. The removal of heat is essential, and the process of liquefaction can only be carried on by cooling the gas during or after compression. Conversely, liquid air confined in a closed and filled receptacle, when allowed to regain the heat lost in being liquefied, would become gaseous and exert a pressure of about six tons per square inch.

That the processes for producing liquid air will be developed so as to reduce the cost to an extent such as to render it available in place of a more ideal gas would be a vain prediction to make at present.

Liquid air consists chiefly of a mixture of four parts of nitrogen to one of oxygen. The presence of the oxygen is a disadvantage, inasmuch as fierce combustion, if not explosion, may be occasioned by bringing the

liquid air into contact with combustibles in presence of a spark of fire. Fine cotton fiber and such like substances soaked in liquid oxygen are highly explosive. It is easy, however, to separate the oxygen from the nitrogen by fractional distillation at low temperatures, or methods may be employed to condense the oxygen separately from the nitrogen. Doubtless, oxygen gas so separated from its companion would have a value in chemical and metallurgical processes. The remaining nitrogen liquefied would be perfectly safe. Can it be transported?

The fact that a three-gallon milk-can of liquid air was brought by Mr. Tripler, of New York, from that city to Lynn, Mass., a journey occupying nine hours, and that not more than one-third of the liquefied gas was lost, although the only covering for heat insulation was about 2½ inches of ordinary steam-pipe felting, goes far toward indicating the possibility of transportation. With a tank of 20 times the linear dimensions of the milk-can referred to, the surface for loss of heat would rise to 400 times while the capacity would have increased 8000 times, and with no better lagging it is easily seen that the daily loss would then be not over 5 per cent. Doubtless, however, improved means for heat insulation would make the loss but a fraction of this amount. If the tank were kept under a pressure of say, 200 pounds to the square inch, a suitable safety-valve being provided to prevent excess of pressure, the evaporated gas or air could be made to do work, specially if superheated. If the tank were in a train the motive power might, at least in part, be derived from the normal evaporation from the tanks. Further, let us imagine a pipe-line well insulated for heat, and it is easy to see that if the velocity of flow equaled the train speed in the journey of the milk-can from New York to Lynn, the percentage loss in a pipe of the diameter of the milk-can with no better lagging than it possessed would be the same or even less. Here again perfection of heat insulation might make quite a saving, and the evaporated gas might, if the line were under pressure, be made available for power along the line of way.

Whether the liquefied gases of the air can be employed in this way will, however, depend upon the development of efficient methods of extracting the heat and effecting condensation of the air. That liquid air possesses no advantage for refrigeration is without doubt true, unless the refrigerating effect be obtainable as a by-product, so to speak, of energy conveyance.

Liquid air represents air compressed to about 800 atmospheres, but existing without pressure. No heavy and excessively strong tanks are needed for storing it. If it be pumped into a closed receptacle under regulated pressure it may be evaporated by the heat of the air, or that of surrounding objects, or it may receive heat from bodies undergoing refrigeration, as water being converted into ice; after which heating operation it may be further heated to the melting-point of lead by heat of combustion, and be finally used in a suitable engine where its expansion may develop power. During its expansion and delivery of power to the pistons of the engine it may become so cooled as to be discharged from the exhaust at nearly normal atmospheric temperature and pressure.

The power expended in compressing and liquefying air is, of course, converted into heat and thrown away. The product, liquid air, has no inherent power of energy in itself. It represents negativity, bearing somewhat the same relation that an exhausted globe does to the surrounding air. It may become the means for rendering the normal energy

to the surrounding air available. Liquid air has capacity for taking up the ordinary heat of surrounding objects and thus acquiring pressure. It can be superheated very efficiently, and so used in the form of compressed air in an engine. The superheating will, of course, tend to raise greatly the total efficiency. The inevitable losses in the compressing and liquefying processes would in part be made up in the added heat, the amount of which is small and efficiently employed. We have no reliable data of large-scale operations, and can as yet reach no certainty as to the efficiency attainable in compression and liquefaction or in recovery of power. It is possible that the separation of oxygen, which would probably possess a value in metallurgy, might tend to diminish the cost of condensation. So also the refrigeration which is obtained during evaporation might help the recovery end. Where so much is "in the air" we must be content with suggestions only, and they may never be realized in practice. The power required to be expended in liquefying a given amount of air can be approximately estimated, and an assumed efficiency of plant may be made to do duty in place of exact figures where none are to be had, and if the conclusions based thereon are understood as tentative and subject to extensive modifications in view of further advances in our knowledge, no harm is done.

In making an estimate of the cost of liquid air as produced on the large scale, the factors of plant-efficiency, maintenance, etc., come in to a greater or less extent. Assuming that air be compressed as nearly isothermally as possible, and that in a large plant a possible total efficiency of 70 per cent. might probably be realized, each horse-power hour might thus be expected to compress nearly 10 pounds of air to a pressure of 2000 pounds to the square inch. If such compressed air, on being expanded in a very carefully arranged self-intensifying apparatus should condense 25 per cent. of the air admitted we would have about 2½ pounds of liquid air per horse-power hour. The assumed proportion, 25 per cent., seems not improbable in view of all the data—meager enough, it is true—which have come to the writer's knowledge.

If the power-cost be taken at $20 per year in large units and an additional charge of $10 be allowed for each horse-power of the compressing and condensing plant, its interest, maintenance and operating expenses, the cost per pound of liquid air would be about one-sixth of a cent, assuming the plant to run 7200 hours per year. This estimate, subject to modification from the very nature of the problem, would make the liquid air cost for production about 8 cents per cubic foot. If oxygen, separated by fractional distillation possessed a value for equal amounts in excess of the cost of the air the remaining nitrogen would, of course, be producible at a lower figure.

It is probably within the possibilities that a cubic foot of liquid air of nitrogen, if allowed to heat from its surroundings and then be further heated to 200 degs. C., could, in a high-pressure engine, yield about five horse-power hours. If at the same time the evaporation of the air were attended by useful refrigeration, as in making ice, the cost of recovery would diminish. Need it be said here, however, that even if the cost of horse-power of recovered energy much exceeded that which is indicated in the foregoing estimates or assumptions, a demand may still exist for a source of power having great compactness, freedom from nuisance, no heated nor noxious exhaust, and of unequalled controllability? The horseless vehicle problem certainly presents us with an instance in point.

It would seem, however, that certain uses may be found for liquid air in which considerations of cost are not so important as is the ability to obtain the effects in view. In warfare, for example, the possession of highly-concentrated energy-stores under control is very important. Liquid air can be rapidly converted into compressed air at six tons per square inch. This would probably be useful in the projection of high explosives. Compressed air is now used for propelling mobile torpedoes, or fish-torpedoes as they are called. Dirigible torpedoes either depend for power upon compressed air or the electric energy of a storage battery. Compressed air requires high pressures and very strong and heavy containing vessels. Liquid air can be stored without pressure or at low pressures, and can be evaporated at any desired pressure, while its bulk represents that of air under 800 atmospheres. A storage battery would probably be from five to ten times as heavy as liquid air in a receptacle, for equal available energy. But no storage battery could be discharged at an equivalent rate.

Submarine boats and flying-machines may yet find use for liquid air. In the submarine boat it could be evaporated by the heat of the surrounding water, and after furnishing power it would ventilate the boat. Before its final discharge it could be burnt with oil in a fuel engine for further power. We may find use for it in the flying-machine. For emergency work it could in evaporating cool the cylinders of a fuel engine and yield power as a result. Moreover, control of the submergence of a boat could be effected by the use of liquid air, so easily gasified, to add to the displacement.

The great feature of the application of such a power as liquid air would be its emergency value. By this is meant the ability to obtain at will a sudden output far beyond the normal. Animal power notably possesses this emergency value, and the success of electric trolley systems largely depends upon the fact that when needed, the station can be called upon for a temporary delivery to any single car or train, of a power greatly in excess of the rated output of the motor.

Suggestions have already been made of the use of liquid air or oxygen, mixed with the combustibles as a high explosive. Such an explosive can be made at the time of use, and if left unexploded, either by accident or design, soon loses its dangerous character by evaporation of the liquid gas.

Liquid air may also be used in the rapid production of high vacua. Let the bulb to be exhausted be filled with a gas, such as carbonic acid, more condensable than air, and be provided with an extension that can at any time be sealed off. If now the extension piece be immersed in liquid air the condensable gas will be taken from the bulb and deposited in the solid state in the extension piece. This is now sealed off, leaving a high vacuum in the bulb, particularly if the same be heated during the process.

A fascinating speculation for the electrical engineer is the possibilities of so cooling the conductors of electric lines or apparatus as to improve the conductivity many times, and so diminish the losses in any given length of conductor, and at the same time greatly improve the insulation. Professors Dewar and Fleming have shown, however, that it is a condition of this enormous improvement in conductivity that the metals be very pure, a very small percentage of impurity greatly lessening the result. As regards the insulation, they have shown that dielectrics and

even electrolytes become insulators of excellent character when cooled to the temperature of liquid air. What effect such a lowering of temperature would have upon the dielectric strength or striking distance between conductors at differences of potential is not as yet determined, so far as the writer is aware. The result to be expected from a consideration of the effect of heating upon dielectric strength or striking distance is that very low temperature will make it far more difficult to break down insulation by sparking through it.

That the electrical engineer covets just such agencies as will thus extend the range of possibilities in his art needs no proof. He would be apt to choose a pipe-line conveying liquid air as the very best location for his conductors, assumed to be made of as pure metal as possible, the high insulation probably attainable being the chief object. Whether his conductors were placed outside such a pipe or within the same, he could no doubt adapt himself to the conditions provided he could get the benefit of the low-temperature insulation, and possibly, to a certain extent, a gain in conduction.

It is indeed very questionable whether a pipe-line will ever be laid and kept filled with liquid air solely for its electrical benefits, but if such a line were also used to supply liquid air to a distant point and the normal evaporation utilized, the case would be somewhat modified, though the improbability of such a combination being put into service, at least within any reasonable period, still remains.

It will be the proper attitude for the conservative and at the same time progressive engineer to await the possession of full and accurate data before drawing any conclusions as to future practice. Suggestions of possibilities are, of course, useful, even if only a fraction of them prove realizable, and no attempt is here made to do otherwise than call attention to matters which must from their nature possess more or less of interest.—*Engineering Magazine* (N. Y.).

THE PRACTICAL TRAINING OF ENGINEER STUDENTS.*

By Mr. Robert Mayston, R. N., Chief Engineer H. M. Dockyard, Devonport.

The engineer students are instructed both theoretically and practically to enable them to become engineer officers in the Royal Navy. For the last eleven years Keyham has been the only admiralty training ground for these officers. The number of students at the present time is 192. An entry is made once each year, during the first or second week in July, following a competitive examination held by the civil service commissioners in the previous April. The period of training is five years. Throughout this time they undergo an educational course at the Royal Naval Engineering College under Professor Worthington, whilst their practical training is obtained in the dockyard at Keyham, and the work they perform is as far as possible real. They take a considerable part in the repair and manufacture of machinery, and in the cases of the two ships which have formed the basis of this paper, they have had a very large interest, more so in the Psyche, for the reason that they have been

* The Institution of Mechanical Engineers at Plymouth. Part of the paper descriptive of the engines of H. M. S. S. Proserpine and Psyche is omitted.

able to follow the manufacture of her engines and boilers right through to the time of the ship going to sea, whereas in the Proserpine the engines and boilers were sent to Sheerness to be fitted in that ship, and the experience to be gained by seeing them fitted on board was not obtainable. As illustrating the part taken in the manufacture of new machinery, reference need only be made to that of the Psyche, and the following work was entirely carried out in the engineer students' fitting shop: The two surface condensers were tubed and tested; the two fire and bilge engines, eight fan engines, two hot-well engines and pumps, two circulating engines and pumps with auxiliary air pump, and the two reversing engines in connection with the slide-valve gear, were completely fitted up from the rough forgings and castings, including all machine and fitting work. In addition, a large number of minor fittings, such as cocks, valves, etc., passed through the hands of the students. It should be noted that the work just enumerated is an indication of what is performed by the students in the early part of their training, that is, during the first half of it, and its class is such as to offer every possible attraction for a student commencing a marine engineering career; at least, this is the object aimed at, and, judging by results, there is every reason to assume that it has been successfully attained. The workshops at Keyham are so close that the students are enabled to watch any erection of new machinery; in fact, it is part of their instruction to be shown the nature of the work as it progresses, and they are afforded every facility. It may be of interest to give the exact training an engineer student undergoes at Keyham during the five years he is under instruction preparatory to his appointment as an assistant engineer, R. N.

First year's training.—On entry he is engaged on practice work with the hammer and chisel, and after a short time commences engine fitting—useful work.

Second year's training.—For nine months he is employed at the lathe, and the remaining three months at other machines. During the second year a half-day per week for the greater part of the year is spent in sketching details of machines and parts of machinery.

Third year's training.—Eight months are spent in engine fitting in the students' shop, one month he is sketching details and learning the principles of construction of machinery used in connection with the discharge of torpedoes, such as air-compressing machinery, torpedo-tubes, both submerged and above-water—the latter as made and placed on board Psyche—and the remaining three months he is employed on repairs to engines, etc., of ships afloat, or as the opportunity presents itself, such as in the case of Psyche, in fitting new machinery in ships. It may here be observed that the testing machine for materials is placed in the students' fitting shop, and arrangements are made for the students in turn to become acquainted with the tests and the methods of carrying them out and of recording them—all very important matters in connection with an engineer's training. All the materials used in the manufacture of Psyche's engines were so tested in order to ascertain if they complied with requirements as laid down in specification; for instance, in the case of the gun-metal used the tensile strength must not be less than 14 tons with an extension in 2 inches of length of 7½ per cent., and in the case of high-tension cast bronze, such as used for the Psyche's propeller blades, the tensile was not to be less than 28 tons with 15 per cent. extension.

Fourth year's training.—The first six months are a continuation of the

last three in the previous year, followed by one month in the coppersmiths' shop, where the short time renders it necessary their work should be more or less of a practical character, such as fitting patches, branches, and flanges, soldering and brazing, becoming acquainted with the method of running white metal into bearings and making sketches of the principal apparatus and processes generally appertaining to coppersmiths' work. This is followed by one month at smithing, in which the work is also of a practical character, such as welding and light forging. Then follow one month in each of the pattern shop and brass foundry, and two months in the boiler shop, in the last of which he obtains knowledge of riveting, tube rolling, etc. With reference to the boiler shop, there are invariably new boilers under construction, and all descriptions come under repair or observation. At the present time Belleville boilers are being manufactured for the Vestal, and tubes are being prepared for boilers of the small-tube type already in existence, including the following descriptions: Thornycroft, Yarrow, Reed, Mumford, Blechynden, Du Temple. Also the Babcock and Wilcox boiler is under observation. During the third and fourth years one evening a week for two hours is appropriated for instruction in drawing, under the direction and supervision of experienced draughtsmen.

Fifth year's training.—One month in the pattern shop and one month in the foundry similarly to fourth year, doing useful work. Three months fitting on ships afloat. Two months are appropriated for obtaining some acquaintance with the elementary principles of ship construction and the fittings of ships. The remaining five months are spent in the drawing-office learning engine drawing and design, the latter part of the time being occupied in the preparation of a drawing from his own sketches, which drawing is required to be done to enable him to pass into the navy. In order that the students may become acquainted with the working of machinery and the duties connected with the engine-room when under way, the Admiralty have set apart H. M. S. Sharpshooter for the purpose, and classes are taken from March till October. During March the ship steamed in the basin, and each third-year student is afforded the opportunities of actually performing the operations of laying and lighting fires, getting up steam, opening and regulating the various valves, attending to the working of the engines and boilers, and learning the various duties of the engine-room. The third-year students are divided into four classes, the course for each class lasting one week, four days under steam, the remaining two days for repairs, examination, etc. From April 1st to September 30th—except during examination and vacation times—the Sharpshooter is steamed under way by fourth and fifth-year students on two afternoons and one whole day a week, when all duties connected with the working of the engines and boilers and examination and repairs after steaming, are carried out by them. Each student by the end of his fifth year has passed through, in addition to the preliminary stage in the third year, four courses of steaming under way, each course of two weeks' duration. At the end of the season the ship is laid up for repairs, which are largely effected by the students themselves during the winter months. It should be noted that the Sharpshooter has triple-expansion engines, and was the first ship in H. M. Navy to be fitted with Belleville boilers, so that the steaming instruction afforded the engineer students by this ship is of very modern character.

Lectures on marine engineering are given to the various years by

officers of the chief engineer's department at Keyham, eighteen per annum to the fifth year, and twelve to each of the other years. The time devoted to the Sharpshooter and to lectures is taken out of the students' working hours in the dockyard, which comprises four forenoons and five afternoons; the two remaining forenoons are devoted to educational subjects distinct from the dockyard, and under the direction of the head master. Sir William H. White, in his presidential address, delivered to this institution in April last, gave the various descriptions of machinery with which the modern warship is now supplied, and it goes without saying that with the growth of this machinery the necessity has increased for giving the officers who will be mainly responsible for its efficiency every opportunity for becoming familiar with it, and of becoming up-to-date naval engineers.

The facilities afforded at Keyham for the acquirement of a thoroughly practical training place the Royal Naval Engineering College in the foremost rank as an institution for obtaining a sound knowledge of mechanical engineering. The fact that as soon as possible after entry the student is employed on useful work, the various courses of instruction which are arranged to render the knowledge of marine engineering obtained as complete and as comprehensive as possible, the facilities afforded for acquaintance with running machinery, the constant contact throughout the training with experienced workmen, the frequent opportunities afforded for obtaining information from the officers who have charge of the training, all go to indicate that nothing is spared to make the training of the engineer student as complete as possible.—*The Engineer.*

OFFICIAL TRIAL OF THE KENTUCKY.

The official trial of the new battleship Kentucky was held on November 24 over the government course from Cape Ann to Boone Island. It was shown that the Kentucky developed a little greater speed than her sister ship, the Kearsarge, which was recently sent over the same course. The contract with the Newport News Shipbuilding and Dry Dock Company, her builders, required that she should develop a speed of 16 knots. The official corrected returns of the government officials showed that the Kentucky made an average speed of 16.897 knots.

The course over which the Kentucky was run is 66 miles long, and it was divided into five sections of .66 knots each, the vessel covering the 33 knots outward and turning making the same distance back. The vessel covered the first leg of the course in 23 minutes 46 seconds, showing a speed of 16.658 knots. On the second leg she covered the distance in 23 minutes 55½ seconds, making a speed of 16.551 knots. On the next three legs she increased steadily until she reached 17.018 knots on the fifth leg, which she made in 23 minutes 13½ seconds. On the return the vessel averaged 16.932 knots, exceeding 17 knots on the first and last legs. The final division of the course was covered in the fastest time made during the day, 22 minutes 57 seconds, or a speed of 17.254.—*Army and Navy Register.*

OUR FASTEST BATTLESHIP.

The Alabama in a preliminary builders' trial has made an average speed of 16.3 knots over a 23-mile course, a maximum speed of 17.2 knots

having been made with the wind and tide, and a speed of 15.43 knots against them. On this occasion the Alabama did not carry any of her guns, and a large amount of her armor had not yet been bolted on, so that she was probably from 1500 to 2000 tons short of her trial displacement of 11,525 tons. At the same time she was undoubtedly very foul as the result of being afloat for over a year at the Cramps' shipyard. It is reasonable to expect that on her official trial, with a clean bottom and under the favorable conditions of the best of coal and expert stokers, she will be capable of repeating the performance in spite of her greater displacement.

The good showing of the Alabama, however, has been eclipsed by that of the Kearsarge, one of the pair of fine battleships that is nearing completion at the yards of the Newport News Shipbuilding Company. This vessel has also been afloat for over a year, the date of her last visit to drydock being August 8, 1898, and on the occasion of her informal trial she carried the whole of her armor, together with the heavy guns of the 13-inch and 8-inch batteries, the only weights not carried being those of the 5-inch guns of the intermediate battery. Hence her displacement and draught were only slightly below what they will be at her official trial. Under these conditions the ship made by log during half an hour's steaming under forced draught a speed of 17.25 knots an hour.

The trial was made in water whose depth varied between ten and twelve fathoms, and it is a well-understood fact (though only discovered a few years ago in the trials of some high-speed cruisers) that a difference of fifteen or twenty fathoms in the depth of water on a trial course will have a very marked effect upon the speed of a deep-draught warship. Hence it is reasonable to expect that when the Kearsarge is put in the trial-trip shape, she will be capable of maintaining an 18-knot average over the deep-sea trial course. If she does this, our latest first-class battleship will easily be our fastest, the Iowa coming next with a trial speed of 17.08 knots per hour.—*Scientific American.*

OFFICIAL TRIALS OF THE SHIKISHIMA.

On May 1, 1897, the first plate of the keel of this vessel was laid, and within twenty-nine months—notwithstanding a six months' delay in the delivery of armor, armament and engines, due to the unfortunate engineers' strike—her trials have been completed to the entire satisfaction of all parties concerned. This probably constitutes a record in the history of battleship building, and the fact that a war vessel of some 15,000 tons displacement and 19 knots speed can be completely built, equipped, armored, armed and engined in a little over two years, speaks volumes for British methods. The vessel having been drydocked at Portsmouth, and her bottom having received its final coating of anti-fouling composition, she left that port for Torbay, to run an eight-knot course in deep water.

The engines worked very well during the whole of the time, indicating upwards of 15,000 horse-power on the measured distance, whereas the contract with Humphrys, Tennant & Co. was 14,500, and she attained a mean speed of 19.023 knots at slightly over her load draught of 27 feet 3 inches. She turned a complete circle in 3 minutes 16 seconds, heeling only 5 deg., her rudder being put from hard over to hard over in 16

seconds, again demonstrating the value of the Cameron gear, actuated by Brown & Co.'s telemotor gear.

Her auxiliary armament was tested with satisfactory results on her way round from Portsmouth, but not the slightest sign of weakness was discovered anywhere, and not a single pane of glass was broken. However, the four 12-inch guns have yet to be fired, which will, of course, test her construction more thoroughly.—*The Engineer.*

The London, battleship, was launched at Portsmouth on the 21st inst. by Lady George Hamilton. The displacement of the London at the time of taking the water was about 5000 tons, including the launching ways, but when completed she will displace 15,000 tons. The new vessel is of the following dimensions: Length between perpendiculars, 400 feet; extreme breadth, 75 feet; mean draught—forward 26 feet 3 inches, aft 27 feet 3 inches. Her inverted, vertical, triple-expansion engines, made by the Earle Company, of Hull, will have an indicated horse-power of 15,000; her boilers are of the Belleville type. Her speed will be 18 knots, and her coal stowage 2040 tons. The complement of the great vessel, when she is ready for sea, will be 773 persons, exclusive of an admiral and his staff, if carried, for whom accommodation is provided. The armament of the London will consist of four 12-inch breech-loading wire guns, twelve 6-inch quick-firing guns, sixteen 12-pounder quick-firing guns weighing 12 cwt. each, two 12-pounder quick-firing guns weighing 8 cwt. each for boat use, six 3-pounder quick-firing guns, and eight .45-inch Maxims. Four submerged torpedo-tubes and fourteen 18-inch and five 14-inch torpedoes complete her powers of offense. The thickness of the armor plating in various parts is thus described: For 216 feet of the sides, 9 inches, tapering beyond this length towards the bow to 2 inches; on bulkheads, 12 inches, 10 inches and 9 inches; on barbettes, 12 inches, 10 inches and 6 inches; on casemates, 6 inches; on fore conning tower, 14 inches, with 8-inch communication tubes; on the after conning tower, 3 inches, with 3-inch communication tubes; on the twelve gun-shields, 8 inches and 10 inches; on the roof and floor of the same, 3 inches of Harveyized nickel steel. The following are the particulars of the protective deck plating: Middle deck between armor bulkheads, two thicknesses of 1 inch, with an extra thickness of 1 inch on the slopes over the machinery spaces; lower deck before forward armor bulkhead, two thicknesses of 1 inch; lower deck abaft after armor bulkhead, two thicknesses of 1 inch and ½ inch respectively; main deck between armor bulkheads, two thicknesses of ½ inch. The London will have two steel masts, each fitted with a military or fighting top, and with a searchlight platform on the main topmast, and a long-distance semaphore for signaling at sea will be fitted. This semaphore is about 160 feet above the level of the water-line. The masts are to be provided with three derricks, two forward and one on the mainmast, and these derricks, primarily fitted for hoisting out the boats, will be of great utility when coaling. The boats include four steamboats, two 56 feet in length and two 40 feet in length, and 14 sailing and pulling boats, ranging from a 42-foot sailing launch to a small dinghy. The two larger are capable of steaming about 13.5 knots, and are fitted with torpedo-dropping apparatus. They will also act as scouts whilst the parent ship is in harbor. Three independent sets of dynamos and engines are required to light the ship, work the

electric motor, fans and searchlights. Every compartment except the double bottom, etc., will be efficiently lit by incandescent lamps.—*Engineering.*

The new battleship Bulwark, launched at Devonport on October 18, was laid down on March 20, and has thus been under construction less than seven months. During that time 5450 tons of material have been built into her, and it is claimed by the Devonport dockyard staff that the work has created records both in the time she has been under construction and in the weight attained for the period. The main dimensions of the ship are: Length between perpendiculars, 400 feet; extreme breadth, 75 feet; draught of water (forward) 26 feet 3 inches, (aft) 27 feet 3 inches; load displacement, 15,000 tons. She will be fitted with two complete sets of engines of the vertical triple-expansion type, of 15,000 indicated horse-power, and is expected to attain a speed of 18 knots. The engines, which are being made by Messrs. Hawthorn, Leslie & Co., of Newcastle-on-Tyne, have cylinders 31½ inches, 51½ inches and 84½ inches in diameter, and a stroke of 51 inches. Each set, in a separate room, is to be capable of developing 7500 horse-power, with 108 revolutions per minute. There will be twenty boilers of the Belleville type. The armament will comprise four 12-inch breech-loading guns, worked in two barbettes, twelve 6-inch quick-firing guns in casemates; sixteen 12-pounder 12-cwt. quick-firing guns; six 3-pounder Hotchkiss quick-firing guns; one 12-pounder 8-cwt. boat gun, one 12-pounder 8-cwt. field gun, and eight .45-inch Maxim guns. She will also have four submerged torpedo-tubes. When commissioned the vessel will have a total of 773 officers and men. The Bulwark and her sister ships are identical in form, dimensions and displacement with the Formidable class, but differ slightly in the distribution of armor protection. In the Venerable class the belt of side armor is carried much nearer the bow than in the Formidable class, while the fore armored bulkhead, which is a feature in the Formidable class, has been dispensed with.—*The Engineer.*

THE U. S. NAVAL ACADEMY PRACTICE SHIP CHESAPEAKE.

For many years the cadets of the U. S. Naval Academy at Annapolis have been compelled to make practice cruises in old vessels fitted temporarily for this purpose, but in reality unfit for the special purposes of training. In 1897, however, Congress took action looking toward the construction of a vessel exclusively for this use. The result is the Chesapeake, built by the Bath Iron Works and now fitting out at the Charlestown Navy Yard, Boston, Mass. Under the advice of the naval officers immediately concerned, at the time, a sailing vessel was decided upon. We do not propose in this article to discuss the advisability of adopting an obsolete type of vessel for the purpose, but simply to describe her construction and arrangements. These and her battery comprise the modern features of the vessel.

Designs for the Chesapeake were prepared by the Naval Bureau of Construction and Repair, under the direction of the Chief Constructor, Philip Hichborn. She is the first sheathed vessel to be built in this country and the only sailing vessel that has been added to the navy in over thirty years.

The original appropriation for the vessel made by Congress in 1897 was unfortunately confused. After deciding that a full-rigged sailing ship was the proper type of training vessel for the cadets, the wording of the bill was such as to include propulsion by both sail and steam, although the estimate in the hands of the committee did not cover such a design. In amending the bill to exclude steam propulsion a great error was committed, as the appropriation was reduced to but $125,000, or one-half the amount required. The design was developed as originally intended, and the contract for the construction of hull and fittings was awarded to the Bath Iron Works, March 16, 1898. Additional funds were made available in February, 1898, the total appropriation being raised to the required amount of $250,000. The keel of the Chesapeake was laid August 2, 1898. She was launched June 20, 1899, and on July 11 she left the yard of her builders and was handed over to the U. S. Government at the Boston Navy Yard. The spars, boats, outfit and furniture have been made at the Boston Yard.

Following are the dimensions and the most interesting particulars concerning the hull of the Chesapeake:

Length over all	223	ft. 6 in.
" L. W. L	175	"
Beam, extreme	37	"
" molded	36	" 3 in.
Freeboard, for'd	14	" 3 "
" aft	14	" 3 "
" amidship	11	" 3 "
Draft, mean	16	" 6 "
" aft	17	" 6 "
" for'd	15	" 6 "
Displacement	1190	tons
Area of midship section	378	sq. ft.
" " load water plane	4570	" "
Tons per inch of immersion	10.86	tons
Meta-centric height	3.6	ft.
Range of stability	120	deg.
Max. righting arm	2.5	ft.
" " moment	2975	ft. tons
Angle of Max. righting arm	58	deg.

The following general schedule of weights will also be of interest:

Hull and fittings	710	tons
Boilers, pumps, piping, etc	45	"
Armament and ammunition	68	"
Equipment and outfit	223	"
Coal	22	"
Ballast	122	"
Total	1190	"

The Chesapeake is a very lean vessel with high freeboard, and closed bulwarks throughout her length. She has considerable deadrise, the angle of her floors being 25 deg. with the horizontal base line. There are three continuous decks, two of which are plated with steel throughout. The steel construction of this vessel is very heavy, and she is sheathed with 4-inch Georgia pine in addition to having a steel bottom and sides fully equal in scantling to any steel gunboat of her size afloat.

Fore and aft water-tight wing bulkheads 62 feet long are worked in the hold amidships. These bulkheads inclose the magazine forward, the boiler-room, the sail-room and the fresh-water tanks aft. In the wings are the electric stores, cadets' stores, medical stores and coal-bunker on the port side, and the ordnance stores, bread-room, warrant officers' stores, equipment stores and coal-bunker on the starboard side.

The boiler-room is 16 feet long and 14 feet 6 inches wide. In it are

located two steel Scotch boilers 8 feet long and 6 feet 6 inches diameter, with single furnaces; a condenser with 150 square feet of cooling surface; an air and circulating pump 4½ by 5 by 6 by 6; a fire and bilge pump 10½ by 6½ by 10; feed pump 4½ by 3 by 6, and a feed tank. The smoke pipe is 3 feet outside diameter, the height above the top of grate being 42 feet. There are 15 fresh-water tanks in the hold. The average size of these independent tanks is 6 feet by 4 feet by 6 feet. The total capacity of these tanks is 15,030 gals. of fresh water. The after magazine is located aft of the tank spaces, the paymaster's stores being on each side of it in the wings.

The ward-room stores and navigation stores are located aft, and the general stores and chain and sand locker are located forward. A trimming tank is located at each extremity of the vessel. On the forward berth deck is located a general storeroom. Then comes the crew's space, divided into two parts by a water-tight steel bulkhead, aft of which is the fire-room hatch, dynamo-room with 2 generators (the plant being in duplicate), distilling-room and refrigerating-room. The evaporation shell is 4 feet diameter and 5 feet 6 inches long over all, size 2-s-120. The distillers are 2-s-98. The evaporator feed pump 6¼ by 4⅜ by 8, and the distiller circulating pump 3 by 2½ by 4. In the refrigerating-room a one-ton Allen dense-air ice-machine is fitted.

On the port side of the berth deck amidships are located the dispensary, sick bay, with bathroom and w. c., paymaster's office and ward-room pantry. On the starboard side the warrant officers' mess-room, carpenters' and boatswain's rooms, and quarters for a few of the cadets. On the berth deck aft is the ward-room, dining-room, ten staterooms and bathroom, complete in all respects. On the gun deck forward is the manger, with lamp-room and small stores. Then comes the cadets' shower-baths and dressing-room, cadets' washroom, warrant officers' and ward-room officers' w. c. on the port side, and the crew's w. c. and cadets' w. c. on the starboard side. A Hyde patent steam capstan windlass with wildcats for 1½-inch chain is located between the wing w. c.'s. The cadets mess and swing their hammocks on the gun deck amidship. Here eight mess tables 12 feet by 3 feet, with seats for fourteen at each table are carried. In the center of this deck are the galleys, pantries, etc., and aft are the executive officer's office, navigator's office, armory, captain's stateroom, cabin, bath, pantry and office. Six 4-inch rapid-fire guns are carried on the gun deck, three on each broadside, two forward, two amidships and two aft, each having 45 deg. angle of fire on each side of a line square with the center line of the ship.

The spar deck of the Chesapeake is a good clear deck fore and aft. A small monkey forecastle is worked forward, the space beneath it being used for the stowage of deck gear. Two 6-pounders are carried forward on the spar or weather deck, two are carried aft, and two 1-pounders are located amidship. A Hyde-Robinson improved hand screw steering gear is located on the deck aft, the vessel having no steam steering gear. Seven boats are carried, viz.: a 30-foot steam cutter, a 30-foot launch; two 28-foot cutters, a 28-foot whale boat, a 28-foot whale-boat gig, and a 20-foot dinghy.

The vessel has no chart or pilot-house, but a large navigating bridge is located aft, just forward of the mizzen rigging. Pin rails, fife rails, topsail sheet bits, cavils, cleats, bits and fair leads are located on deck to the best possible advantage.

The Chesapeake is a full-rigged sailing ship, with three masts spreading 19,975 square feet of sail all told; the area of the ten principal sails is 13,131 square feet. The fore truck is 130 feet above the water-line, the main is 142 feet, and the mizzen is 115 feet. The following gives the lengths of the yards and fore and aft spars:

Fore lower yards	68 ft.
" topsail "	51 ft. 6 in.
" topgallant "	34 ft.
" royal "	24 ft. 3 in.
Main lower "	78 ft.
" topsail "	66 ft.
" topgallant "	45 ft. 9 in.
" royal "	33 ft.
Mizzen lower "	51 ft.
" topsail "	38 ft.
" topgallant "	25 ft.
" royal "	18 ft.
Fore spencer gaff	27 ft.
Main " "	27 ft.
Spanker gaff	35 ft. 6 in.
" boom	53 ft. 6 in.
Jib boom outboard	41 ft. 3 in.

The center of effort of the sail is 8.33 feet forward of the center of lateral resistance and 57.95 feet above the water-line.—*Marine Engineering.*

THE CHILIAN TRAINING-SHIP GENERAL BAQUEDANO.

It is a noteworthy feature of the present age that, at a time when masts and yards are utterly dead for warships, all nations not merely adhere to sail-power for their training-ships, but actually build vessels for the purpose, in which steam is merely an auxiliary. It means, of course, a general recognition of the value of sails and the working of them in the making of sailors—a certain carelessness of life being thus imparted, which is not to be acquired in any other way. There is, further, the physical training, which is better in exercises aloft than in the formal physical drill on deck. There are some indeed who have argued that the stokers would be better for "drilling in the sky"; and in so far as training stokers in deck duties has improved their physique as a class, there is possibly something to be said for the matter. In the Russian Navy it is said that something of the sort has been actually done.

However, at present masted training-ships are only intended for the men whose duties lie in working guns, and for executive cadets, who are particularly supposed to need sky drill. The first vessel built in modern times to be primarily a sailing training-ship was the Benjamin Constant, a Brazilian vessel launched at La Seyne in 1892. Her speed is merely a nominal 14 knots, though she carries the rather powerful armament of four 6-inch and eight 4.7-inch quick-firers upon special mountings, designed, we believe, at Elswick. She had too good an armament, however, for a Brazilian training-ship, and so has drifted into being a cruiser. Originally she was full-ship rig; now the main has altogether been removed, the fore and mizzen cut down and made into military masts. Indeed, we have heard that the Brazilians have been adding or subtracting military tops to and from the foremast of the Constant ever since.

Russia set afloat the next training-ship—the Vernii, a vessel without any steam motive power at all. Subsequently and recently Argentina and Chili concluded that each needed a training-ship. The former power

ordered the Sarmiento at Laird's; while Chili ordered the Baquedano at Elswick. In both ships the same main idea obtains—sails as the chief motive power, steam as an auxiliary, while each carries an armament, so that in war time she shall not be useless. And carrying as they do the latest thing in artillery, they might be formidable antagonists to older and more powerful ships in those waters.

Comparing the two, we see how similar is the general idea:

	Presidente Sarmiento.	General Baquedano.
Launch	1897	1898.
Displacement	2750 tons	Circa, 2300.
Armament, all quick firers	Five 4.7-in	Four 4.7-in.
" "	Two 14-pounders	Two 12-pounders.
" "	Four 6-pounders	Two 6-pounders.
" "	Four 3-pounders	
" "	Four machine	Two Maxim guns.
Torpedo tubes	Two	One 18in.

Both are full-rigged, single-screw ships, with speeds of about 13.5 knots. The remaining details of the General Baquedano are: Length, 277 feet; extreme breadth, 45 feet 9 inches; depth, 25 feet 2 inches; mean draught, 18 feet.

She is built of steel and sheathed with teak, and is designed to carry a complement of about fifty officers and 250 men. Her length over all is 277 feet; breadth extreme, 45 feet 9 inches; depth, 25 feet 2 inches; mean draught, 18 feet; and her displacement, about 2300 tons. She is barque-rigged, having a sail area of about 17,500 square feet, and carries vertical triple-expansion engines of 1500 indicated horse-power, built by Messrs. Hawthorn, Leslie & Co., driving a single screw, of the Bevis patent feathering type. Her boilers, four in number, are of the Belleville water-tube type, and she has bunker capacity for 350 tons of coal. During her recent steaming trials she attained a speed of 13.75 knots.

She carries a 28-foot steam launch, which steams at a speed of 7½ knots per hour; and nine other boats, one of which is specially fitted to carry submarine mines. She can accommodate 14,500 gallons of fresh water in her tanks, and has distilling plant capable of producing about 4400 gallons per day.—*The Engineer.*

THE FRENCH AND RUSSIAN NAVY ESTIMATES.

The French Navy Estimates for 1900, just issued, show some interesting changes. The total vote is $60,000,000, which is $2,000,000 more than in the previous year. The greater part of this increase is due to guns, just as Russia's is due to harbors and guns. For construction purposes, $20,000,000 are asked, and this is $230,000 more than in the current year, but it may be remembered that $400,000 of a supplementary vote was granted, so that the expenditure next year will really be less than in the current year. It has not been decided what new vessels will be ordered, but there is a fairly large programme to advance, although it is made up mostly of small craft. The two Estafette cruisers of 4000 tons and 26 to 27 knots speed have yet to be ordered; the elements of design with this high speed are not so easy of solution. The other ships laid down this year include two battleships, one at private works and the other, the Marseillaise, at Brest; two submersible torpedo-boats at the government dockyards and four by contract; four squadron torpedo-boats by contract, eleven torpedo-boats, four torpedo-boat destroyers, two river gunboats

building in England—the Argus and Vigilante. Thus, of the total vote for new construction only about $5,000,000 is to be spent on new construction, while $4,200,000 is to be devoted to repairs, etc. The vote for guns shows an increase of $1,300,000, the total being $6,000,000, of which $5,500,000 is for new weapons, due to the requirements of new vessels, auxiliary cruisers, and new coast batteries. The addition of men for active service has involved an increase to many of the votes. The total augmentation of the personnel is 2145, of whom 1350 are in the first-class reserve, which is thus brought to 5903. The sea service includes 35,673, an increase over the current year of 623, and the land service 4815, an augmentation of only 172. This addition to personnel has rendered necessary some economies in several directions, and a careful examination of all the details indicates that the principal effort is being directed to perfecting of the munitions of war already possessed rather than to the accumulation of new war material. In one or two cases there will be substituted new for old ships, but any change numerically is towards reduction. Thus the Foudre and the transport Japon are to be withdrawn from the Mediterranean fleet "for reasons of economy." The instructional division is to be reduced, one of the six coastguard ships and three of the cruisers are to be passed into the first-class reserve. The Northern squadron has also been strengthened, and will cruise for longer periods. The two river gunboats building in London are for participating in the work of exploration in China, and they will be ready early in 1900.

The Russian Naval Estimates for 1900 have been prepared, and they total $48,500,000, as compared with $46,000,000, an increase of two and one-half millions; but the significance of the increase is more marked when it is noted that at the beginning of this decade 22 millions was considered a large expenditure on the Russian Navy, irrespective of special naval schemes, which are now the fashion in Russia as with other nations. The shipbuilding vote comes to $16,000,000, which is rather less than in the previous year, but fully double that of 1890. This is partly due to special votes for the navy scheme that extends over a period of years. The guns and electric fittings, which are not included in this shipbuilding sum, require 5 millions, against $1,600,000 in 1890. The wages of the effective staff, which is some measure of the strength at peace times, is $2,600,000, as compared with $1,900,000 in 1890; and in non-effective service—for administration, dockyard staffs, etc.—nearly half a million more is required. An interesting feature of the estimates is the sum required for new strategic harbors. In the current year $2,000,000 was voted for Libau, or, as it is officially termed, Port Imperator Alexander III, and for Vladivostock. Next year there will be spent at the first-named $1,000,000, at Vladivostock $1,600,000, and at the new Far Eastern Russian port of Port Arthur, which appears in the estimates for the first time, the same amount. Thus, for the three harbors over five millions is to be voted, as compared with $2,000,000 in the current year.

The French Parliamentary paper (Etat H) embodying the shipbuilding programme has just been presented to the Chamber. It includes 112 vessels of all classes, of which 22 are described as completed and 67 as in hand, while 23 are proposed or begun. In the first category are the battleships Charlemagne, Saint Louis, and Gaulois, the commerce-destroying cruisers Guichen and Châteaurenault, two third-class cruisers, one gunboat, and 14 various torpedo craft. The largest of the vessels

in hand are the battleships Henri IV, Jéna, and Suffren, and the armored cruisers Jeanne d' Arc, Dupetit-Thonars, Gueydon, Condé, Gloire, Dupleix, Kléber, Desaix, Montcalm, Sully, Marseillaise, and Admiral Aube. The various torpedo craft in the list are 10 destroyers and 38 boats of other classes. The vessels in hand are classified as follows in regard to their anticipated dates of completion:

	1900.	1901.	1902.	1903.	Total.
Battleships	2	1	..	..	3
Armored cruisers	1	5	3	3	12
First-class "	1	..	..	..	1
Destroyers	6	..	4	..	10
Gunboats	3	..	..	..	3
Submarine	3	..	6	..	9
Squadron torpedo-boats	6	4	..	..	10
First-class "	9	9	..	..	18
Turbine torpedo-boat	1	..	..	..	1
Totals	32	19	13	3	67

The shipbuilding programme for 1900 is in a sense provisional. M. de Lanessan has announced his attention of presenting a scheme for the increase of the fleet, but is expected to take the advice of the chiefs of the navy, and will be heard on the subject by the Budget Committee. The principal vessels now proposed to be laid down are two battleships, A 8 and A 10 (Brest and Toulon), the largest yet built in France, and an armored cruiser, C 11 (Cherbourg). The plans of the battleships indicate a displacement of 14,865 tons; length, 439 feet; beam, 78 feet 9 inches; stern draught, 27 feet 6 inches; armament, four 12-inch breech-loaders, eighteen 6.4-inch, twenty-six 1.8-inch, and two 1.4-inch quick-firers, and five torpedo-tubes, of which two are submerged; vertical triple-expansion engines of 17,475 indicated horse-power, supplied by water-tube boilers, and driving three screws, to give a speed of 18 knots; normal coal capacity, 905 tons; extreme, 1825 tons; complement, 42 officers and 780 men. The armored cruiser is intended to displace 12,416 tons, with a length of 475 feet 9 inches; beam, 71 feet 2 inches; draught, 26 feet 3 inches; armament, four 7.6-inch, sixteen 6.4-inch, two 1.8-inch, and four 1.4-inch, and five torpedo-tubes, of which two are submerged; vertical triple-expansion engines of 24,000 indicated horse-power, supplied by water-tube boiler, driving three screws, and giving a speed of 21 knots; coal capacity, 1350 tons; complement, 23 officers and 687 men.—*Engineering.*

THE TRANSPORT OF TROOPS.

A great fleet of vessels has been hastily chartered for the conveyance of an army corps to the war now being waged against the Boers in the South African Republics, amounting to nearly 150 ships whose aggregate tonnage exceeded 670,000 tons. That is a large fleet; but, as we pointed out some time ago, in dealing with our great merchant fleet, it forms a comparatively small proportion of the shipping owned by Britain, so that it might have been possible, under certain conditions, to have chosen even more conveniently equipped and faster vessels. As regards speed, we find that two of the vessels can steam 18½ knots, both Castle liners; one 18 knots, an Orient liner; one 17½ knots, an Anchor liner; two 17 knots, a Cunard and P. and O. ship; two 16½ knots, a Cunard and White Star vessel; two 16 knots, an Orient and an Allan vessel; three 15-knot vessels, all Castle liners; four 14½-knot P. and O. boats, and one Union

steamer. It is no part of our duty to discuss politics, and we therefore pass from this matter of choice with the remark that when the need for transports was recognized the Government was able to secure the ships without seriously discommoding our merchant service. Since a large proportion of the troops came from India, it was only to be expected that the British India Steam Navigation Company should supply the largest contribution of any line—twenty-five vessels of 90,575 tons. Then come several lines each with seven large vessels, including the Castle Line, Elder, Dempster & Co., the Cunard Company, and the Union Line. The tonnage of the Castle liners was 41,263 tons; but, in addition, they have sent a large number of troops and munitions of war by their ordinary steamers. Up till now they have sent 10,127 officers and men, including General Buller and his staff, and they have also had the satisfaction of landing the first of the army corps this week.

The Kildonan Castle is the most important of the troopships yet sent from this country. This vessel was only launched on August 22 by the Fairfield Company, and was to be handed over in February next; but on October 6 she was chartered by the Government, 3000 men were put on board by the Fairfield Company, first to tear out such passenger cabins, etc., as minimized the space which could be given over to troops, and subsequently to construct such special fittings as were necessary to accommodate 3000 men. The work was completed within three weeks, and the vessel sailed on November 4, and will land next week at the Cape 96 officers, 2225 men, six horses, a large consignment of Royal Engineers, pontoon building, balloon, and other equipment, besides many guns and much ammunition, and all within three months of her launch as a steel shell—a performance eminently creditable to the Fairfield management and to the Castle Line. Kits and lifebelts are stowed on temporary timbers between the deck beams, and these again carry the hooks for the hammocks, which during the day are stowed along the casings. The tables are collapsible and may be disposed of in a few minutes. Two decks are thus arranged. At the forward end there is an armory where there are stored, tier upon tier, over 3000 rifles and other arms. Forward also there are four cells in the ward-room, one of them well padded with straw. Aft there is a ward hospital, so arranged as to be divisible into separate and isolated wards. The ordinary cuisine is very extensive, but additional kitchens were fitted. The electric light will be a joy to the soldiers, no matter in what part of the ship they are, and the matter of ventilation has had special attention. Another important point is that 13,000 gallons of drinking water can be distilled each day, so that the little army which is now afloat in the vessel have special comforts.

A word may here be said also of the splendid arrangements made by the London and South-Western Railway for the transit to, and embarking at, Southampton of the troops. Nearly one-half of the troops sent to South Africa have embarked at Southampton. Up to the end of last week 26,578 men, 906 officers, about 100 horses, and a large number of guns, etc., have been despatched from the southern port in twenty-three vessels totalling 34,336 tons gross. Some of these, however, were regular liners, not troopships in the usual sense. The figures do not include such non-combatants as doctors, nurses, etc. The southern port has proved itself admirably suited for the work; the Empress Dock and the new wharf which stretches down Southampton Water have been used. The railway runs alongside the steamers, and on the wharves there are a

large number of hydraulic cranes running on rails. Thus guns, carriages and horses, etc., were quickly embarked. On one day five steamers were despatched, taking with them, besides government stores, 167 officers, 4756 men, 24 horses, 38 vehicles and five guns. All five vessels left between 2.30 P. M. and 4.30 P. M. Nine transports, several of them vessels of 5000 and 6000 tons, were alongside at the same time, besides the ordinary liners. The company, too, have won golden opinions for the facility with which they have dealt with the railway traffic incidental to the embarking of the troops. To entrain and pass over the main line within a few hours 5000 or 6000 men with their accoutrements, in addition to the usual heavy traffic, was a splendid feat alike for the general manager and locomotive superintendent.—*Engineering.*

NON-FLAMMABLE WOOD.

Paper read before the British Association by Mr. E. MARSHALL FOX.

The author commenced by saying that more than sixty years ago the subject received attention at the hands of Faraday, who demonstrated that there were many chemicals possessing the property of rendering wood more or less uninflammable. Among the chemicals found by him and other experimenters to be adapted for this purpose, have been tungstate of soda, silicate of soda, boracic acid, borax, sulphate of magnesia, aluminum and sulphate of lime, all of which gave some measure of success in laboratory experiments, but it is only quite recently that non-inflammable wood has become a product of practical utility. No more immediate or pressing need for wood that will not catch fire exists than in ships of war. The naval engagements between the Chinese and Japanese fleets in 1894 showed that fire is a potent factor, for the woodwork on the Chinese warships Tung Yung, Chao Yung, Lai Yung and Yung Wei caught fire from the shell of the enemy and brought about the destruction of those ships. Early in 1895 the Secretary of the American Navy appointed a commission to examine into a new process for rendering wood non-inflammable to which his attention had been called. As the result of such examination the product was placed experimentally on two American cruisers then building, and after several months of trial, during which it gave the fullest satisfaction, its use was extended to other American ships of war. In the summer of 1897, however, a re-examination of the subject was ordered by the United States Government, owing to reports that the treated wood presented difficulties in its working and painting, and sometimes corroded metals in contact with it, and absorbed more moisture than ordinary wood. The result of such re-examination was that the Government approved its use and extended it to all the new ships of war then under construction, and in many cases much of the woodwork of ships already in commission was taken out and non-inflammable wood substituted. At the present time nearly all the woodwork of the principal warships of the United States consists of non-flammable wood. The vulnerability of ships fitted with ordinary woodwork was strikingly shown in the naval engagement off Manila in May, 1898, between the warships of the United States and Spain, when the Reina Christina, Castilla, Don Juan de Austria, Velasco, and other Spanish ships were destroyed by their woodwork catching fire from the American shell. The immunity against risk of

fire of ships fitted with non-flammable wood was demonstrated a few weeks afterwards in the naval engagement off Cardenas, Cuba, when the American torpedo-boat Winslow and the gunboat Wilmington were several times hit by Spanish shell, the former being shot through and through, yet no fire occurred on either vessel, both being fitted with non-flammable wood. In the naval engagement off Santiago de Cuba on July 3, 1898, the American ships, though struck many times with shot and shell, suffered no damage from fire, while the Spanish ships, Maria Theresa, Almirante Oquendo and Viscaya, were destroyed by conflagration caused by the American shell through setting fire to their woodwork. Some two years ago the Admiralty commenced testing wood treated by the process employed in the American warships with the result that after several months of trial, such wood was specified for the woodwork of the Royal yacht, and also for the various battleships, cruisers and torpedo-boat destroyers now in course of construction. Samples of the wood treated were shown by the author. The method of treatment consists in placing the wood in closed cylinders of steel, and then subjecting the wood to alternate applications of heat and steam for definite lengths of time, after which the steam is blown off and the air exhausted from the cylinder; a solution consisting of fireproofing and antiseptic chemicals, the principal ingredient of which is phosphate of ammonia, is then admitted. The pressure pumps are then put in operation and the liquid forced into the pores of the wood. The cylinders used for the purpose measure 100 feet in length, and 7½ feet in diameter, and consist of ⅞-inch steel, tested to a pressure of over 300 pounds, per square inch. The door is an important feature of the cylinder, as it must be made to resist great pressure without leakage of air or liquid. It weighs 7 tons and is secured by an arrangement of radial bolts that cause it to effectually resist the pressure. The wood to be treated is placed on low-wheel trolleys, with space between each board to admit of the solution penetrating all around, and the trolleys are run on trucks into the cylinders. The degree of heat, steaming, vacuum and pressure varies according to the character of the wood under treatment; hard woods being treated in different cylinders from the soft woods, and requiring a different treatment. The time required in the cylinders varies according to the kind of wood being treated. Not all woods are amenable to the process, some because of the large quantity of resin or oil that they contain, and some because of the irregular character of their fibers resisting impregnation. Teak, Austrian oak, and American pitch pine are particularly resistant, and require much longer and more drastic treatment, to be made uninflammable. Yellow deal, white pine, mahogany, ash, elm, walnut, birch, cherry, and English oak, on the other hand, lend themselves readily to the treatment. The thickness of the wood forms an important feature. Of the softer woods, 3 inches to 4 inches in thickness can be impregnated, but in harder woods rarely more than 2 inches can be thoroughly treated. For all practical purposes, however, it has been found in tests that impregnation of 1 inch on all sides renders the wood non-flammable throughout. The amount of solution taken up by the softer woods is greater than that absorbed by the harder, and varies in the different natures. White pine and yellow deal take, as a rule, more than double their original weight. This feature necessitates different strengths of solution for various woods in order to obtain uniformity in the degree of non-flammability imparted. After the wood has become thoroughly

impregnated, it is removed from the cylinders and dried, leaving the resultant fireproofing chemicals deposited in the pores. The thorough drying of the treated wood is of the greatest importance, and is accomplished by placing it in kilns, where a uniform temperature of dry air, not exceeding 120 deg. Fahr., is kept in constant circulation by means of rotary fans. After the wood is thoroughly dry it is ready for use.

The author next proceeded to give details of a number of trials made which appeared to fully prove the fire-resisting nature of the process he described. He also exhibited before the meeting some experiments proving the non-flammable nature of the treated wood.—*Engineering.*

ELECTRIC AUXILIARY MACHINERY IN THE UNITED STATES NAVY.

By Alton D. Adams.

Since the tests on board the Minneapolis by Mr. W. W. White, which showed that her steam auxiliaries consumed 119 pounds of water per horse-power hour on the average, especial attention has been turned to the subject of electric driving. The plan for electric driving is, briefly, to substitute for each small auxiliary steam engine an electric motor of equal capacity, and to install enough electric generators, directly connected to compound engines, for the maximum demand of these motors at any one time. Efficiency is the great advantage that has been claimed for the electric equipment, as it is readily shown that compound engines, electric generators, and motors require only about one-third the weight of steam per hour demanded by the small engines now in use for the same work. This decided gain in efficiency is quite generally admitted, but the various arguments for and against the proposed change have been in some cases amusing rather than instructive.

For instance, one writer has said, "At the same time it is impracticable to install on board ship dynamos of more than 1000 amperes, so that thirteen dynamos would be required to give the necessary power at 80 volts," but has not explained the mysterious reasons which would prevent dynamos giving 5000 or 10,000 amperes working to that entire satisfaction on warships which they commonly give on shore.

Again, another recent writer has said: "Such a voltage (80 or 100) is, however, entirely unsuited for a 1000 horse-power plant. The weight of the distribution system would not only be excessive, but the size and weight of the generators would be prohibitive," although the facts are that the weight of conductors for the distances on board ship, at 100 volts pressure, would probably not exceed 10 per cent. of the present steam-pipe weights for the same work, and that the change from 100 to 250 or 500 volts pressure would not decrease the weight of electric generators more than 5 per cent.

An increase in pressure of electric plants on warships is to be desired in order to diminish somewhat the cost of electric conductors, and the care of brushes and accumulators; but this is a decidedly minor matter, and failure to abandon the present standard voltage should not be stated as fatal to electric driving. Conclusions as well as arguments differ on this subject, one having said: "We are driven, therefore, irresistibly to the conclusion that, although electric auxiliaries offer very many advantages, their great cost and the amount of space they would occupy render

a complete installation of them of doubtful benefit, while their great weight makes it absolutely out of the question."

Another concludes that "The electric plant, with the generating sets described, will weigh between two and a half and three times the steam drive," but later says that "The space required for 200 to 400 tons of coal is available in addition to that space at present allotted for dynamo room." The writer is unable to agree with either of the above views, first, because the total weight of machinery necessary for electric driving is less than that required with steam alone; and secondly, because it seems improbable that, with the pressing demand for greater steaming radius, any coal space will be given up to machinery, even though the coal consumed by auxiliaries is reduced. If the relative weights of equipment for steam and electric driving are necessary as above stated, it may well be feared that the introduction of the electric motors and dynamos for the work is to be a slow and uncertain change, but it can easily be shown that such is not the case. The solution of this entire question, the proven efficiency and reliability of electric driving being granted, depends directly on the test of weight for the electric and steam equipment, and by this test the future applications of one or the other must be largely decided.

The weights usually quoted in matter on the subject of electric driving are for engines and dynamos of about the same construction as is common in those machines for use on land, in which cast iron is largely used, a metal having less than one-half the value of wrought iron and steel in strength and magnetic properties. The extended use of cast iron in the main engines and other machinery of warships ceased to be good practice some years since, and there is no good reason why driving engines for dynamos and electric motors should not be constructed with special view to light weight for use on shipboard. The great weight of electric equipment and its driving engines on board warships is probably due to the fact that while the main engines and machinery in war vessels are usually built on plans of the government engineers, or under their rigid specifications as to materials and weights, the electric equipment has been substantially the same as that in common use on land as to materials and construction. It is true that the navy regulations limit the weight of engines and connected dynamos complete to one-third of a pound per watt of output, or $746 \div 3 = 248.6$ pounds per horse-power output; but this specification amounts to but little, as manufacturers can ill afford to make generating sets heavier than this, since even cast iron is costly in large quantities. When upward of $500 per ton is paid for armor plate, main engine shafts are forged hollow, and all the general machinery in warships is designed for the required strength with minimum weight, there seems no good reason why electric equipment should not be required of the smallest weight consistent with the best results, without regard to any slight increase in cost. The truth, perhaps, is that electrical machinery being of comparative recent use in the navy, has not received that attention from government engineers that has been given to other branches. The efficiency of electric equipment for driving auxiliaries on warships has been placed at higher figures, but the writer believes the following to be as good results as could regularly be attained in practice.

Combined compound engines and dynamos may be expected to have an efficiency of about 80 per cent. if worked at nearly full load, and

electric motors and conductors also 80 per cent. under at least three-fourths full load. Above efficiencies give for the ratio of power delivered by motors to the indicated horse-power of engines, as $0.8 \times 0.8 = 0.64$, or 64 per cent.

Any good compound engines should develop indicated horse-power at the rate of 1 horse-power on 20 pounds of steam per hour, and an allowance of 25 pounds steam per horse-power hour, in consideration of some underloading and other losses, is liberal. At an average of 25 pounds of steam per indicated horse-power hour, and a combined efficiency of 64 per cent., the steam consumed per horse-power hour delivered by the electric motors is found by $25 \div 0.64 = 39$ pounds, or only $39 \div 119 = 0.328$, or about 33 per cent. of the steam required for steam-using auxiliaries in the Minneapolis test. Stated in another way, the electric equipment would save $119 - 39 = 80$ pounds of water per horse-power hour delivered at the motors. Taking the capacity of auxiliary equipment in a battleship at 2400 brake horse-power, it may be safely assumed that not more than one-half this auxiliary capacity will be in use at any one time, or 1200 horse-power delivered. With line and motor combined efficiency at 80 per cent., the power required from dynamos will be $1200 \div 0.80 = 1500$ horse-power, and that from engines $1500 \div 0.80 = 1875$ horse-power, combined engine and dynamos efficiency being 80 per cent.

At the government limit of 248.6 pounds per horse-power output from dynamos of generating sets, the weight of engines and dynamos to deliver the 1500 horse-power will be $248.6 \times 1500 = 372{,}900$ pounds. The weight of medium-speed motors, as commonly made, may be taken at 100 pounds per brake horse-power output, so that the total weight of the 2400 horse-power for auxiliaries will be $2400 \times 100 = 240{,}000$ pounds.

The weight of steam engines driving auxiliaries in warships will probably average 125 pounds per brake horse-power, and in many cases they exceed this figure. The weight of 2400 horse-power engine capacity at 125 pounds per horse-power is $2400 \times 125 = 300{,}000$ pounds for the steam drive.

Summing up above weights, the following results for a ship plant to deliver 1200 horse-power to auxiliaries aggregating 2400 horse-power total capacity:

	Pounds.
Total weight engines and dynamos to deliver 1500 horse-power	372,900
Total weight electric motors	240,000
Total weight of electric equipment	612,900
Total weight steam drive for 2400 horse-power	300,000
Excess of electric equipment over steam engines	312,900

All comparisons between the machinery required by the two systems that have come to the writer's notice stop at the point just reached, and thereby overlook a very important factor in total weight.

It has been shown above that the saving of the electric over the purely steam drive is 80 pounds of steam per hour for each horse-power delivered to auxiliaries, so for 1200 horse-power delivered to auxiliaries the hourly saving in steam with electric driving is $80 \times 1200 = 96{,}000$ pounds. A low figure for the weight of boilers and attachments is 5 pounds per pound of steam per hour capacity, so that the boiler equipment for the 96,000 pounds steam required by direct steam driving over that for the electric is $96{,}000 \times 5 = 480{,}000$ pounds additional. As the total boiler capacity necessary for the main engines must be had at the same time

the total boiler capacity for the auxiliaries is wanted, the total boilers in the ship must be the sum of these two and the 480,000 pounds in boiler capacity above mentioned can be omitted with electric driving. A proper amount of feed water must be carried for the main engines in addition to that for auxiliaries, so that the 96,000 pounds of feed water required by direct steam driving over the electrical per hour may also be omitted from the ship, since water would not be returned to boilers more than once per hour. Taking these weights of boiler plant and feed water saved by the electric system in connection with the figures above found gives the following:

	Pounds.
Weight of steam driving of 2400 horse-power capacity	300,000
Extra weight of boilers required	480,000
Extra weight of feed water required	96,000
Total for steam driving not required in electric	876,000
Total for electric driving	612,900
Saving in weight by electric driving	263,100

From this it is evident that electric driving, instead of being so heavy, compared with direct steam as to forbid its introduction, actually effects a saving in weight equal to a large part of that of engines in direct steam driving. But the comparison is not yet complete, since the weights stated above for the electric system are based on those common in land plants, and it is by no means necessary or desirable to use such heavy machines on board ship as the present navy regulations allow. It is interesting to note in some detail by what constructions the weights of driving engines, dynamos and motors may be reduced. Compound engines, as now offered by most makers, weigh from 100 pounds to 150 pounds per indicated horse-power complete, including the extended bases to receive dynamos. Frames, bases, and cylinders of these engines are mostly of cast iron, while crank shafts, connecting rods and piston rods are of solid forged steel or steel castings. The improved construction desirable for light weight involves the substitution of steel castings for cast iron in bases and cylinders on account of its greater strength, hollow-forged steel frames in place of cast iron, and hollow-forged steel crank shafts, connecting rods and piston rods for the solid steel forgings and castings now used for these purposes. The lighter construction of connecting rods, piston and piston rods, makes the high rotative speed so desirable for dynamos more easily attainable. The net result of such improvements on compound engines is to reduce their complete weight, with extended bases for dynamos, to 60 pounds or less per indicated horse-power.

A few engine-builders have made use of this improved construction for light weight, and with their general requirement for marine work there is no reason why this method of building should not become common. A good illustration of several of the features of construction is found in the drawings for new U. S. battleships Nos. 10, 11 and 12, shown in Commodore Melville's recent report. The weights of most electric generators offered for direct connection vary with different makers from about 100 pounds to 150 pounds per kilowatt, or from 75 pounds to 112 pounds per horse-power output at the brushes.

Many of these dynamos for direct connection have cast-iron armature spiders and magnet frames, which should be replaced in an improved construction for light weight by steel castings or wrought-iron forgings. The proportions of many dynamos offered for marine work should also

be so changed as to shorten magnet cores and increase somewhat the per cent. of copper compared with iron, as in this way the total weight of many dynamos can well be reduced. With the improvements above indicated the total weight for direct-connected marine generators may be readily reduced to not more than 75 pounds per kilowatt, or 57 pounds per horse-power output at the brushes. Seventy-five pounds per kilowatt output by no means marks the ultimate of improvements in the matter of weight, but is an actuality of material already attained by some large makers in their regular machines. Improvements to reduce the weight of small and medium-sized motors, as in the case of large dynamos, is to be attained by the substitution of steel castings and wrought-iron forgings for cast iron, and in this way a weight of not more than 75 pounds per brake horse-power capacity can easily be attained, and has, in fact, been surpassed in a number of cases.

With an efficiency as above of 80 per cent. for the engine and electric generator combined, for each horse-power of electric energy delivered at the brushes the engine must develop $1 \div 0.8 = 1.25$ indicated horse-power. The weight of engine per horse-power delivered at the dynamo brushes will therefore be from the above $1.25 \times 60 = 75$ pounds, and with the weight of dynamos at 57 pounds per delivered horse-power, the complete weight of generating set is $75 + 57 = 132$ pounds per horse-power of electric energy, or $132 \div 746 = 0.17$ pound per watt output at brushes, instead of 0.33 pound per watt, or 248.6 pounds weight per horse-power output at dynamos as allowed by the navy limit. That these reduced weights are not too low is shown by the fact that they are slightly bettered at this time by makers who have adopted the improved constructions above indicated in some sizes, while at least one large manufacturer who still uses cast iron for engine bases, frames and cylinders, offers regularly for marine work generating sets weighing about 160 pounds per kilowatt, or 120 pounds per horse-power output at the dynamo brushes. With the improvements above outlined fully carried out, there seems no reason to doubt that the regular weight of combined compound engines and dynamos for marine use can be reduced below 100 pounds per kilowatt, one-tenth pound per watt or 75 pounds per horse-power output of electrical energy at the dynamo brushes.

Basing weights of electric-plant equipment for a first-class battleship on actual attainments, as above pointed out, instead of the more common practice and the navy limit, the weights of electric driving will be as follows:

	Pounds.
Weight engines and dynamos to deliver 1500 horse-power equals 1500 × 132 equals	198,000
Weight 2400 horse-power capacity electric motors equals 2400 × 75 equals	180,000
Weight of driving engines, dynamos, and motors equals	378,000
Weight of 2400 brake horse-power steam engines equals 2400 × 125 equals	300,000
Weight of extra boilers required as above found equals	480,000
Weight of extra feed water required as above equals	96,000
Steam driving equipment not required by electric equals	876,000
Electric driving equipment not required by steam equals	378,000
Saving in weight by the electric equipment equals	498,000

Instead, therefore, of the prohibitive weight, or one two and a half to three times that necessary for direct steam drive, electric driving

actually saves a weight of total equipment greater than the total weight of small engines used for auxiliaries without electric equipment. It will be noted that above figures for the saving in weight do not include the difference in coal burned by steam and electric driving, though to be entirely fair to the electric system this should be considered, the reason for omitting the weight of saved coal being that it seems hardly probable that the amount of coal will be reduced, even though some is saved from auxiliaries, as there is great need of more for main engines than it is at present possible to carry, since much of the value of a battleship depends on the distance she can travel at a given speed without recoaling. There is, however, one particular in which the weight of coal saved by use of electric driving must be considered—namely, its cost, as this has a direct bearing on the possible saving with the electric equipment. The electric plant will perhaps cost more than the direct steam system, and it should be noted whether the saving in coal offers a suitable inducement for the increased investment.

One writer has said that "The first cost of the electric system would be about three times that of the steam system," and that "The electrical system could not be expected to pay for its increased first cost in less than five or six years of constant use." How accurate are these statements may appear from the following: The use of auxiliaries in ships is intermittent, but from the best data at hand an average use of one-fourth their total capacity for twenty-four hours daily seems a fair estimate. Direct steam-driven auxiliaries of 2400 horse-power capacity, on the basis of one-fifth average load during twenty-four hours per day, consume, at the rate found in the Minneapolis test, steam to the amount of $(2400 \div 5) \times 24 \times 119 = 1{,}370{,}880$ pounds daily, which at 8 pounds of steam per pound of coal burned, requires $1{,}370{,}880 \div 8 = 171{,}360$ pounds, or $171{,}360 \div 2240 = 76.5$ tons of coal daily.

For electric driving, taking only 39 pounds of steam per horse-power hour at the motors as above, the steam consumed on the same assumption for average load is $(2400 \div 5) \times 24 \times 39 = 449{,}280$ pounds daily, which as above, amounts to $449{,}280 \div 8 = 56{,}160$ pounds, or $56{,}160 \div 2240 = 25$ tons of coal per day. The saving in coal for this case by electric driving is then $76.5 - 25.0 = 51.5$ tons per day, which at so low a price as $6 per American ton amounts to the sum of $57.5 \times 6 = \$345$. Cost of equipment for above electric plant on battleship may be fairly taken at the following figures:

Compound engines and dynamos to deliver 1500 horse-power at $50 equals	$75,000.00
Electric motors to deliver 2400 horse-power at $25 equals	60,000.00
Electric wiring and fittings for above equals	50,000.00
Total	$185,000.00

Direct steam driving requires 96,000 pounds more steam per hour than electric driving, as found above, and taking the cost of boilers and fittings at the low price of 50 cents per pound of steam per hour capacity, these additional boilers will cost $96{,}000 \times 0.5 = \$48{,}000$, and the 2400 horse-power capacity of small steam engines at $20 per brake horse-power will cost $2400 \times 20 = \$48{,}000$, making a charge of $10,000 for the extra steam-piping of direct steam driving, brings its total cost up to $106,000.

The total charge for electric equipment equals	$185,000.00
The total charge for steam equipment equals	106,000.00
Additional cost of electrical equipment equals	$79,000.00

Cost of fuel alone for the steam system was found above to be $345 per day more than that for the electric system, and this saving by the electric equipment amounts, therefore, to $345 \times 365 = \$125{,}925$ per year, so that the extra cost of electric system can be paid for out of the coal saved in about $79{,}000 \div 125{,}925 = 0.62$ year, or less than seven months. A just appreciation of the facts on which the above figures are based seems certain to result in the rapid adoption of electric driving for auxiliaries throughout the navies of the civilized world.

In spite of the great advantages as to weight and efficient operation inherent in the electric system for warships, the navies of the United States and of the world are slow to avail themselves of it. So far as the writer is informed, the first complete electric driver of auxiliaries is yet to be installed on a first-class battleship, and in most cases the electric system is confined to a few of the less important auxiliaries. To illustrate how generally steam is still used to drive battleship auxiliaries, the following data concerning the United States seagoing battleship Iowa have been taken from the account of her contract trial by Passed Assistant Engineer J. M. Pickrell, United States Navy, and printed in the Journal of the American Society of Naval Engineers of August, 1897.

The Iowa was contracted for at a price of $3,010,000, her length on water-line is 360 feet, beam 72 feet 2.75 inches, and displacement corresponding to normal draught 11,340 tons. On trial trip the Iowa's main engines developed 11,834 horse-power, and though the auxiliaries in use at that time developed only 236 horse-power, there is good reason to think that the total horse-power of auxiliary equipment is about 2500. Aside from the main engines there are eighty-four auxiliaries in the Iowa, with a total among them of 146 steam cylinders.

From the Minneapolis tests and the similarity of operation of auxiliaries on different warships, it is fair to assume that these 146 steam cylinders will consume about 119 pounds of steam per horse-power hour, instead of the 25 pounds to 40 pounds per horse-power hour that would be used in compound engines for the electric system. The electric plant of the Iowa includes four generating sets, each with capacity of 300 amperes at 80 volts, or 24 kilowatts, a total of but 96 kilowatts capacity for the four sets. Each generator is directly connected to a simple two-cylinder engine, each cylinder being 10½ inches diameter and 5 inches stroke, running at 400 revolutions per minute, and using steam at 80 pounds pressure.

Each generating set complete—engine, bedplate and dynamo—weighs about 8500 pounds, or nearly 35 pounds per watt of output. These generating sets supply current for about 500 incandescent lamps, four search-lamps, and the following electric motors: Two electric motors of 2 horse-power each are used to drive fans that ventilate the dynamo-room; four motors of ¼ horse-power each are used to drive portable fans which exhaust air from various compartments; eight motors of 7 horse-power each work the ammunition hoists in the 8-inch turrets; and seven other motors of about 5 horse-power each are used on ammunition hoists in other parts of the ship.

The Iowa, then, may well serve to illustrate the lack of electric plant and motor driving rather than what sound reasoning shows can and should be done in this direction. This high-grade seagoing battleship with modern armament, from her 12-inch guns down to those of rapid-fire; with an armor belt of Harveyized steel 14 inches thick, and with main engines triple expansion, and a water consumption of probably less than 20

pounds per horse-power hour, is using 146 steam cylinders for auxiliaries that are quite certain to consume more than 100 pounds of steam per horse-power hour.

The worst feature of these conditions is that they exist when it can be certainly shown by calculation and from actual plants on land that an electric equipment would do the same work with less than 40 pounds of steam per horse-power hour, and have less weight. Yet the Iowa has not been selected as a particularly bad example, but simply as a fair example of the great lack of electric power equipment in the navies of the world.

To sum up the case for electric driving in warships, the following facts are pertinent: The electric motor for hard and continuous work at all stages of load and overload, is in no way second to the steam engine, as shown by the tens of thousand of motors in use for electric traction under street cars, exposed to mud and water in all kinds of weather and to most severe overloads that would stall an engine in the same place and of equal rated capacity. Electric wires cut by shot in time of action simply put the apparatus to which they serve current out of use until the break is made good—usually but a matter of a very few minutes—while a steam pipe cut under the same conditions would be a serious menace to life in a close compartment, and would require much more time for repairs. Electric wires are so small and their temperature so nearly constant that they may be run about the ship with much less inconvenience and danger to other constructions, as men's quarters and water-tight compartments, than is the case with the much larger and hotter steam pipes.

For the same combined capacity of auxiliaries the complete weight of driving equipment from boiler to motor is less by a large percentage with electricity than with steam, as shown above. The electric system will deliver a horse-power hour to the driven machinery with less than four-tenths the coal consumption necessary where individual steam engines are used. The net result with the electric equipment, all other things being equal, is a lighter ship or greater coal capacity, a greater steaming radius or higher speed, and for ordinary operations in times of peace a material reduction in the yearly expense for coal. Of what value these features are to a great navy in peaceful maintenance or aggressive warfare, those whose positions impose the obligation may well decide.—*The Engineer.*

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Sec. 1. The Institute shall consist of regular, life, honorary and associate members.

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